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REPORT ON THE COMPREHENSIVE SURVEY OF THE WATER RESOURCES OF TH--ETC(U)

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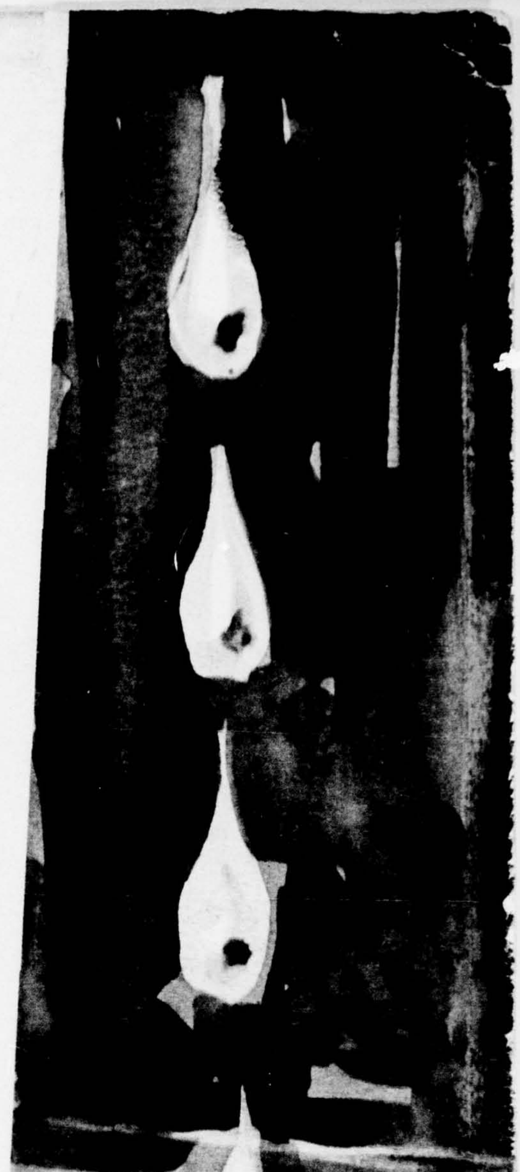
U.S. ARMY ENGINEER DISTRICT PHILADELPHIA
U.S. ARMY ENGINEER DIV. • NORTH ATLANTIC

DELAWARE RIVER BASIN REPORT

DEC. 1960

VOL. I

MAIN REPORT



ADDRESS REPLY TO:
DISTRICT ENGINEER
U. S. ARMY ENGR. DIST., PHILA.
P. O. BOX 8629
[illegible]DELPHIA 1, PA.

REFER TO:

(1)

U. S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
CUSTOM HOUSE—2ND & CHESTNUT STREETS
PHILADELPHIA 6, PA.

NAPEN-R

15 November 1961

SUBJECT: Delaware River Basin Report

TO: Division Engineers, except Division Engineer, MD
District Engineers, except District Engineers of Eastern Ocean, Far East and Okinawa Districts and Districts in MD

1. The District Engineer, Philadelphia, recently completed a report on the comprehensive study of the water resources of the Delaware River Basin. In view of present emphasis on comprehensive basin planning, the Division Engineer, North Atlantic, proposed to the Office of Chief of Engineers that each Division Engineer and District Engineer office having Civil Works responsibilities be furnished a copy of that report as source material.

2. The Office, Chief of Engineers, concurred that such distribution was desirable, and requested that the distribution be made by the District Engineer in order to avoid rehandling. Accordingly, one complete copy of the District-Division report on the Delaware River Basin is furnished each addressee except those who were previously furnished copies in compliance with specific individual requests. The exceptions, to whom this letter is being furnished for information, are:

a. Division Engineers:

Ohio River
Lower Mississippi Valley
New England

NAPEN-R 15 November 1961
SUBJECT: Delaware River Basin Report

b. District Engineers:

Baltimore
New York
Washington
Norfolk
Ft. Worth
Pittsburgh
Galveston
Rock Island
Huntington
St. Louis

1 Incl
Del.R.Basin Rpt (11 vols)
w/addendum & errata sheets
Cy. No. 2/2

T. H. SETLIFFE
Colonel, CE
District Engineer

cc: OCE, Attn: ENGCW-PD
NAD, Attn: NADEN-R
Director, WES, Vicksburg

U. S. ARMY ENGINEER DIVISION, NORTH ATLANTIC
CORPS OF ENGINEERS
90 CHURCH STREET
NEW YORK 7, NEW YORK

27 December 1960

IN REPLY REFER TO

NADEN-R

SUBJECT: Delaware River Basin Report

TO: Chief of Engineers
Department of the Army
Washington, D. C.

1. I concur in the conclusions and recommendations of the District Engineer contained in his report on the Delaware River Basin dated December 1960.

2. The report presents a plan for coordinated long range development of the water resources of the Delaware River Basin. The plan has been developed through the joint efforts of all Federal and non-Federal governmental agencies concerned. Every effort has been made to insure that the plan represents the optimum with respect to conservation and development of the basin water resources and economy of cost. It is pertinent to emphasize, however, that the intricate and interrelated structure of the plan may be nullified by continuing encroachment and incompatible development of the project areas unless a vigorous program for preservation of the sites is undertaken at an early date. A proposal for such action is included among the District Engineer's recommendations.

T H Lipscomb

T. H. LIPSCOMB
Brigadier General, USA
Division Engineer

1

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REPORT ON THE COMPREHENSIVE SURVEY OF THE WATER RESOURCES OF THE DELAWARE RIVER BASIN. Volume I.

Main Report.

PREPARED BY
U. S. ARMY ENGINEER DISTRICT, PHILADELPHIA
VALLEY REPORT GROUP
RUSSELL MORGAN, CHIEF

New 410358

DECEMBER 1960

Revised May 1961

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12 305p.

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DELAWARE RIVER BASIN REPORT

VOLUME INDEX

COMPREHENSIVE REPORT ON THE DEVELOPMENT OF THE WATER RESOURCES OF THE DELAWARE RIVER BASIN

SYLLABUS

Recent disastrous flooding and authorizations by the U. S. Supreme Court for diversions out of the basin of 900 million gallons of water per day for water supply purposes focused attention on the need for control of the high and low flows in the Delaware River Basin. In water use studies based on present and projected populations and economic activities in the basin and adjacent areas, it was found that the primary needs that could be satisfied by water resources development were flood control, water supplies, recreation and hydropower. Present and projected needs for navigation, preservation of water qualities, preservation of fish and wildlife resources, sediment control, and drainage, create no direct requirements for added or expanded development of the water resources of the basin.

All practical measures to satisfy the needs of the basin were considered including land management measures, local protection works, reservoirs of all sizes, a saltwater barrier in the Delaware River estuary, and supplemental programs capable of satisfying significant portions of the needs. The economies and capabilities inherent in major impounding structures for multiple use required that the basic plan be defined in terms of major control projects with small reservoirs and other measures and programs added as supplements to mitigate the needs and to extend the effectiveness of the plan.

A total of 193 major reservoir potentials in the basin was considered. A series of evaluations defined a basic plan of 19 major control projects. The basic plan and the multiple-purpose elements of the plan were designed, on the basis of maximized net benefits, to provide, in a balanced and timely manner, for control of flood flows, control of low flows for water supply purposes, enhanced recreation opportunities and hydropower generation. A total of 386 small reservoir projects was also considered, and a series of discrete screenings identified 39 projects with sufficient economic attractiveness for flood control purposes to warrant their inclusion in the plan of development. All of these small control projects can be accomplished under existing authorizations and continuing programs. The physical features of needed land management programs also can be accomplished under existing authorizations and continuing programs. Since the effects of such measures on downstream flows are modest, the actual extent and nature of the physical features were not defined in this investigation.

The District Engineer recommends that a plan consisting of 19 major control projects and 39 small control projects, at an estimated total construction cost of 591 million dollars, be adopted as a guide to the timed and balanced development of the water resources of the basin. He recommends that authority be granted for the construction of eight major control projects indicated to be needed in the next 30 years at an estimated total Federal first cost of $134,900,000 plus $89,100,000 which would be reimbursable by local interests for water supply storage, a total of $224,000,000, and annual operation, maintenance and replacement costs of $2,450,000 during the period of deferred use of future water supplies and $2,260,000 during the period after use of future water supplies is initiated; provided local interests bear annual operation, maintenance and replacement costs of $266,000 during the period of deferred use of future water supplies and $450,000 during the period after use of future water supplies is initiated. The District Engineer recommends, also, that a program be established and executed at an early date for the acquisition of project lands in order to preserve the project sites.

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Senate Resolution 148, 85th Congress
1st Session, follows the
plates of the Main Report.

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TABLES (Cont'd)

PLATES

CHAPTER I

INTRODUCTION

1. SCOPE. The water resources of the Delaware River Basin contribute to the economic and social well-being of an important segment of the economy of our nation. To anticipate the requirements that will be placed on these resources in the future and to plan for their continued beneficial use, an investigation has been made. It was necessary, first, to define these requirements and, secondly, to establish a plan of development that will assure the satisfaction of these requirements through a balanced utilization of these limited resources. This report constitutes the official account of these investigations. It defines a comprehensive and rational plan for control of the uneven flows of the Delaware River and its tributaries to the practical and economical extent required to insure its optimum and equitable restraint and availability for every purpose in the future, thereby providing for the continued expansion of the Delaware Basin community. The ultimate value of the plan as a guide to the development of the basin's water resources depends on the continuation of vigorous activity by government and non-government interests wherever such interests are engaged in the development and use of the water resources of the region. The plan presented in this report was formulated on the basis of technical studies and investigations participated in by the several levels of government through their representative agencies within the Delaware River Basin area, each within its sphere of responsibility to the people of the basin.

2. The following chapters of this report contain the results, conclusions and recommendations of the District Engineer based upon analysis of detailed technical data and investigations reported upon in the various appendices to this report. Information gained by careful review and evaluation of reports of prior studies of the Delaware River Basin, as well as that obtained by new field surveys and extensive new office studies and investigations, is contained therein.

3. BACKGROUND OF INVESTIGATION. Interest in the waters of the basin is not new. Numerous independent surveys and reports on many facets of the basin's waters have been prepared for various purposes in the past. Such purposes encompassed local, state, interstate and Federal interests. The history of planning for the development and utilization of the water resources of this basin dates from the early 1800's when a number of shallow draft barge canals were designed and constructed to carry the anthracite of the Lehigh, Schuylkill and Susquehanna basins to Philadelphia and New York. In 1823 the Corps of Engineers formulated plans for a breakwater at the mouth of Delaware River to protect vessels from storms and floating ice. Since that time numerous studies have been made, by the Corps of Engineers, for

navigation improvements on the Delaware River and Bay. These have resulted in construction of 6 major navigation projects with authorized depths in excess of 25 feet, and a number of projects with authorized depths under 25 feet. A navigation channel 40 feet deep from the ocean to Philadelphia has been completed and is being extended to Newbold Island thence 35 feet deep to Trenton.

4. Use of the Delaware River and its tributaries as a source of municipal and domestic water supply can be traced to the late 1700's with the building of municipal waterworks at Bethlehem and Philadelphia. In the 1920's, New York City contemplated going to the headwaters of the Delaware River for an additional water supply. Continuous negotiations of the States of New York and New Jersey and the Commonwealth of Pennsylvania at that period failed to provide any acceptable solution to their mutual water supply problems. A resolution to this particular phase of the basin's water resources development came through a decree of the Supreme Court in 1931 which granted the City of New York the right to a diversion of 440 million gallons per day (mgd). That decree required that New York release from its reservoirs a limited quantity of water to maintain minimum flows. The negotiations undertaken by the basin states at that time recognized the need for comprehensive treatment of the water resources of the Delaware basin.

5. In 1933 the Corps of Engineers completed preliminary studies of the Delaware River that were submitted to the Congress and became part of the nationwide study known as the "308" report. The section of that report concerning the Delaware basin, published as House Document No. 179, 73d Congress, 2d Session, dealt with navigation, hydroelectric power, flood control, irrigation and water supply. Although no development features were found economically justified at that time, the report marked the beginning in the Delaware River Basin of a more comprehensive approach to water resources development and use.

6. Two years after publication of the "308" report, the Interstate Commission on the Delaware River Basin (INCODEL) was created by reciprocal legislation in New York, New Jersey, Delaware and Pennsylvania. From its creation through 1948, INCODEL directed its program mainly to the problem of pollution in the Delaware River Basin. INCODEL then undertook a study and prepared a report, published in August 1950, dealing with a comprehensive plan for the Delaware River Basin. That report included plans for water supply storage, hydroelectric power, pollution abatement, recreation, fish and wildlife, stream flow regulation and salinity control. Although the proposed plan failed of ratification by all the member states, it remains as a major contribution in the history of resource development in the basin.

7. Following World War II, work was resumed on the New York City system of reservoirs in the Delaware headwaters. In 1954 the Pepacton Project was completed and added to previously completed system comprised of the Neversink Project and the Rondout Project, the latter in

the adjacent basin. In the same year the Supreme Court approved an additional diversion by New York City to a total of 800 mgd. The diversions are subject to specific conditions and obligations regarding compensating releases and sewage treatment. The decree limits diversion to 490 million gallons per day until completion of the Cannonsville Project on West Branch of Delaware River, and 800 million gallons per day thereafter. This decree also granted the State of New Jersey the right to divert 100 mgd from the basin without compensating releases.

8. A general Federal interest in the water resources development of the basin has been active throughout the years. The United States Department of Agriculture has long been active in various elements of the land use program, agricultural drainage, land treatment measures and flood control on small watersheds. The United States Department of Interior has been active in the basin in matters relating to fish and wildlife, recreation, stream gaging, geologic studies and management of historical resources, and commercial fisheries. The United States Department of Health, Education and Welfare has conducted numerous studies and pursues continuing programs related to the quality of the waters of the basin. The United States Department of Commerce continues to maintain data collection activities pertinent to navigation and climatology. The Corps of Engineers has been active in the areas of flood control and navigation. Corps of Engineers' reports of particular interest include the review report on the Lackawaxen River, a major tributary of the Delaware River, which was published as House Document No. 113, 80th Congress, 1st Session. This document recommended authorization for construction of Dyberry (now Edgar Jadwin) and Prompton Dams and Reservoirs for flood control. Of equal importance is the review report on the Lehigh River, published as House Document No. 587, 79th Congress, 2d Session, which recommended authorization for the construction of Bear Creek Dam and Reservoir and local flood protection works for the cities of Allentown and Bethlehem. House Document No. 358, 83d Congress, 2d Session, recommended authorization for a channel in the Delaware River for navigation, 35 and 40 feet deep from Philadelphia upstream to the vicinity of Trenton, New Jersey. A 40-foot channel from Philadelphia to the Sea, was authorized in accordance with recommendations in Senate Document 159, 75th Congress, 3d Session. All of these projects have been completed, or they are under construction.

9. In addition to the long record of studies on the Delaware River by Federal agencies, a considerable number of technical investigations, covering various aspects of water use and development have been made for portions of the basin from time to time by the States, counties and municipalities, and other interests. The recently completed plan for the Brandywine Basin development made by the Commonwealth of Pennsylvania, in cooperation with the Brandywine Valley Association and Federal and other local interests is a notable example.

10. <u>AUTHORIZATIONS FOR INVESTIGATION</u>. Since the preparation of the "308" report in 1933, significant changes have occurred in the

region's population and economy. The population has increased about 30 percent, total personal income about 81 percent, total employment is up about 25 percent with employment in factories increasing about 33 percent, and per capita personal income has increased about 40 percent. These changes influenced local interests to request that the "308" comprehensive report for the Delaware River Basin be brought up-to-date. Accordingly, the Committee on Public Works of the United States Senate directed, by a resolution dated 13 April 1950, that the "308" report be reviewed to determine whether any modifications in the recommendations of that report were advisable.

11. Limited review of the "308" report was in progress in August 1955 when two tropical storms moved up the eastern coast of continental United States about a week apart. The flood damage and other destruction resulting from these storms dramatically emphasized the need for full appraisal of the water problems of the Delaware basin. This increased interest led to the adoption of the following resolutions by the Committee on Public Works of the United States Senate:

a. Resolution dated 14 September 1955, requesting a review of previous reports on the Delaware River and a number of other streams in northeastern United States, to determine the need for modifications of the recommendations of previous reports and the advisability of adopting further improvements for flood control and allied purposes.

b. Resolution dated 14 November 1955, requesting a review of the "308" report and other reports on the Delaware River with a view to determining the feasibility of providing flood protection measures in the New York area of the watershed.

c. Resolution dated 20 February 1956, requesting a review of the "308" report and other reports with a view to determining the feasibility of the United States and the Commonwealth of Pennsylvania and the State of New Jersey constructing and operating, on a cooperative basis, a reservoir on the Delaware River near Wallpack Bend or Tocks Island as an integral unit of a comprehensive plan for control and utilization of the water resources of the Delaware River in the interest of flood control, navigation, water supply, stream pollution abatement, recreation, control of the movement of salt water, electric power and other purposes.

12. On 13 June 1956, the Committee on Public Works of the House of Representatives adopted two resolutions as follows:

a. Resolution 640 requested a review of reports on the Delaware River and its tributaries to determine the feasibility of providing flood protection measures in the New York portion of the watershed.

b. Resolution 643 requested review of reports on the Delaware River and its tributaries to determine whether any improvements for flood control and allied purposes are advisable, particularly in the counties of Northampton and Monroe and the city of Easton, Pennsylvania.

13. Even as work was underway on the studies of the water problems of the basin, an intense but short duration drought occurred in 1957 and directed further attention to the nature and extent of these studies. This led to a resolution dated 28 April 1958 by the Committee on Public Works of the United States Senate. This resolution requested a review of reports on the Delaware River, in conjunction with the comprehensive study, to determine the feasibility of constructing a barrier in the Delaware estuary. Consideration was directed to the economic and physical effects; the costs and potential benefits; and the economic and physical relationship of such a structure to other works of improvement being planned for the basin.

14. The full texts of all resolutions pertaining to this investigation are contained in the documented history of this report presented in appendix A referred to below.

15. <u>COOPERATION AND COORDINATION</u>. It was apparent that to carry out the intent of the Congress as indicated in the above resolutions the Corps of Engineers, as the responsible agency, would have to call upon and work closely with all Federal, State and local agencies involved in the region's economy. Public hearings, meetings within and between the States and agencies involved, and other actions in conformity with the need for coordination were initiated early in the study. The more significant actions of this type are described in Appendix A, "History of Investigation." The letters referred to below and reproduced in that appendix are pertinent examples:

a. A letter dated 11 September 1956 from the Assistant Secretary of the Army to the Under-Secretary of Interior which outlined the basis on which the Corps of Engineers sought the cooperation of other agencies; and

b. A letter dated 22 October 1956 from the President of the United States to the Secretary of the Army which directed the Department of the Army to exercise particular care throughout the survey and in the preparation of this report to solicit and take into account the comments and views of the Federal agencies and the affected States and municipalities.

16. To assure the full range of coordination found to be necessary, two important steps were taken. The first was the establishment of the Delaware Basin Survey Coordinating Committee composed of representatives of the Federal agencies and major non-Federal entities participating in the planning. The second was the making of specific assignments for accomplishment of studies and preparation of the report. The Coordinating Committee, of which the District Engineer, U. S. Army

Engineer District, Philadelphia, acted as permanent chairman, convened at about four-month intervals to review progress of the work and to coordinate matters pertaining to the report. The Coordinating Committee was constituted as indicated below. The listing of more than one member indicates successive agency representation.

Agency or Interest Represented	Committee Member
U. S. Department of the Army	Col. Allen F. Clark, Jr. Col. W. F. Powers Lt. Col. F. A. Gerig, Jr. Col. T. H. Setliffe
U. S. Department of Agriculture	Fred H. Larson Alvin C. Watson
U. S. Department of Commerce	S. L. Taylor August Schofer
U. S. Department of Health, Education and Welfare	Sylvan C. Martin
U. S. Department of the Interior	D. R. Gascoyne Mark Abelson
U. S. Department of Labor	John F. Foy
Federal Power Commission	John H. Spellman
Commonwealth of Pennsylvania	Maurice K. Goddard
State of Delaware	Richard A. Haber
State of New Jersey	Joseph E. McLean Salvatore A. Bontempo
State of New York	Thorndike A. Saville Ronald B. Peterson
City of Philadelphia	Samuel S. Baxter
City of New York	Irving V. A. Huie (deceased) Vincent G. Terenzio Arthur C. Ford

17. ASSIGNMENTS. The overall planning and coordination of this report effort was achieved by the U. S. Army Engineer District, Philadelphia. To fulfill the assignment, the Corps of Engineers made detailed studies and prepared reports on the history of the investigation; basic hydrology; flood damages; needs for supplies of water;

need for navigation improvements; hydroelectric power potentials; formation of the plan of development; and the costs and benefits appraisals for the impounding structures, the salt water barrier, recreation developments and elements of the recommended plan. Also, the Corps collaborated in investigation of recreation needs and small reservoir potentials. To realize the full benefit of the capabilities of the cooperating agencies, the following assignments were made:

a. U. S. Department of Agriculture. The Forest Service, Agricultural Research Service and the Soil Conservation Service prepared reports dealing with the agricultural resources of the basin, supplies of water for irrigation and rural use, land treatment measures, and watershed protection and management programs. The Soil Conservation Service collaborated with the Corps of Engineers in the study of upstream reservoir needs and potentials and, also, collaborated with the Geological Survey, U. S. Department of the Interior, in studies on sedimentation in the basin.

b. U. S. Department of Commerce. The Office of Business Economics, in this Department, made an economic base survey covering population and economic projections. The Weather Bureau furnished certain meteorological data. The Bureau of Public Roads reviewed proposals for highway relocations and provided needed coordination with existing highway programs.

c. U. S. Department of Health, Education & Welfare. The Public Health Service made an inventory of municipal and industrial water use,a survey of present stream quality with projections of future quality under augmented flow conditions, appraisals of quality of water to be impounded in proposed projects, and studies of insects of public health importance and their control.

d. U. S. Department of the Interior. The Geological Survey made an inventory of ground-water resources of the basin. It also collaborated with the U. S. Department of Agriculture in the study of sedimentation. The National Park Service, with the assistance of the four States and of local recreation interests, prepared a recreation plan for the basin, and collaborated with the Corps of Engineers on studies of recreation needs. The Fish and Wildlife Service prepared studies pertaining to the fish and wildlife resources of the basin.

e. U. S. Department of Labor. Although having no specific tasks in preparation of the report the U. S. Department of Labor representative was available for consultation on labor costs and labor problems.

f. Federal Power Commission. This Commission furnished the studies of market and value potentials for hydroelectric power as contained in its report in appendix F and collaborated with the Corps of Engineers in other power studies required for the report.

18. Non-Federal agencies, represented on the Delaware Basin Survey Coordinating Committee, participated in the studies and report as follows:

a. States. The four States furnished valuable information and technical review capabilities throughout the investigation and preparation of the report. The State of Delaware, in addition, set up coordinating procedures among its state agencies and prepared a comprehensive report on its land and water resources.

b. Municipalities. The City of Philadelphia and New York City supplied needed information and provided valuable technical review of the planning processes.

19. Contribution by Others. In addition to the Federal and non-Federal contributions discussed above, acknowledgment is made of the large number of individuals, organizations and public and quasi-public agencies, which contributed to this report. While it would be impractical to cite all these contributors, some of those more directly concerned, are mentioned here.

a. The contributions of the Delaware River Basin Advisory Committee and its affiliate, Water Research Foundation, Inc., including its report on administrative organization have been substantial. The Interstate Commission on the Delaware River Basin has been particularly helpful. The Atlantic States Marine Fisheries Commission, and the colleges and universities of the area, provided valued consultation and advice on various technical aspects of the planning. The Atomic Energy Commission and the U. S. Department of the Navy provided information pertaining to their respective areas of interest.

b. Local utility companies contributed experience and technical capabilities in the investigations for hydroelectric power development by participating in a Power Work Group. This group was composed of utility representatives from the Pennsylvania Power and Light Company, Public Service Electric and Gas Company, General Public Utilities Company, Philadelphia Electric Company, Orange and Rockland Utilities Company, and the New York State Electric & Gas Corporation, as well as representatives from the Federal Power Commission and the U. S. Army Engineer District, Philadelphia. Data provided by this Work Group have been incorporated into the report on hydro-power potentials of the basin (appendix T).

20. APPENDICES. The reports on the various cooperative efforts referred to above are contained in the following appendices to this report:

Appendix	Title	Author Agency
A	History of Investigation	U. S. Army Engineer District, Philadelphia, U. S. Department of the Army

Appendix	Title	Author Agency
B	Economic Base Survey	Office of Business Economics. U. S. Department of Commerce
C	Water Use and Stream Quality	Public Health Service U. S. Department of Health, Education & Welfare
D	Flood Damages	U. S. Army Engineer District, Philadelphia, Department of the Army
E	Navigation	U. S. Army Engineer District, Philadelphia, Department of the Army
F	Power Markets and Valuation of Power	Federal Power Commission
G	Water for Irrigation and Rural Use	U. S. Department of Agriculture
H	Fluvial Sediment	Geologic Survey, U.S. Department of the Interior and Soil Conservation Service, Department of Agriculture
I	Recreation Resources	National Park Service, U. S. Department of the Interior
J	Fish and Wildlife Resources	Fish & Wildlife Service, U. S. Department of the Interior
K	Use and Management of Land and Cover Resources	U. S. Department of Agriculture
L	Insects of Public Health Importance	Public Health Service, U. S. Department of Health, Education and Welfare
M	Hydrology	U. S. Army Engineer District, Philadelphia, Department of the Army
N	General Geology and Ground Water	Geologic Survey, U. S. Department of the Interior
O	Intrastate Water Resources Survey, State of Delaware	State of Delaware

Appendix	Title	Author Agency
P	Gross and Net Water Needs	U. S. Army Engineer District, Philadelphia, Department of the Army
Q	Formation of the Plan of Development	U. S. Army Engineer District, Philadelphia, Department of the Army
R	Water Control at Intermediate Upstream Levels	Soil Conservation Service, Department of Agriculture, and U. S. Army Engineer District, Philadelphia, Department of the Army
S	Salt Water Barrier	U. S. Army Engineer District, Philadelphia, Department of the Army
T	Hydroelectric Power	U. S. Army Engineer District, Philadelphia, Department of the Army
U	Project Designs and Cost Estimates	U. S. Army Engineer District, Philadelphia, Department of the Army
V	Benefits and Cost Allocations	U. S. Army Engineer District, Philadelphia, Department of the Army
W	Recreation Needs and Appraisals	National Park Service, Department of the Interior, and U.S. Army Engineer District, Philadelphia, Department of the Army
X	Operating Organization	Water Research Foundation for the Delaware River Basin.

21. HEARINGS. Two series of public hearings were held by the District Engineer, U. S. Army Engineer District, Philadelphia. The first series was held early in the studies to secure the views and desires of various local interests, organizations, and individuals in the objectives and outcome of this investigation. Hearings in this series were held at Philadelphia, and Stroudsburg, Pennsylvania; Port Jervis, New York; Trenton, New Jersey; and Wilmington,

Delaware. The second series of public hearings was held after the general plan of development was firmly defined, to explain the plan and its objective to local interests and to obtain their views of this plan. Hearings in this second series were held at Reading, Pennsylvania; Port Jervis, New York; Phillipsburg, New Jersey; and Wilmington, Delaware. Transcripts of all the hearings were prepared in a limited number of copies to accompany the submission of this report, and are on file in the U. S. Army Engineer District, Philadelphia. Summaries of the record of each of the hearings are contained in appendix A.

22. In addition to these public hearings, local interests initiated a number of public meetings throughout the basin. Representatives of the various participating agencies and organizations appeared at these meetings as the study progressed and explained various aspects of the planning process. The general public was also invited to attend the meetings of the Delaware Basin Survey Coordinating Committee, where progress on phases of the work was reported and technical aspects of the investigations were discussed.

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CHAPTER II

DESCRIPTION OF BASIN

23. LOCATION AND SIZE. The Delaware River drains a relatively long and narrow area in the northeastern United States. The area extends approximately 265 miles southward from the western slopes of the Catskill Mountains in New York to the Atlantic Ocean at the mouth of Delaware Bay, between Cape May in New Jersey and Cape Henlopen in Delaware. The basin width varies from 40 miles to 80 miles. The center of the basin lies on approximately the same latitude as New York City and is about 80 miles west thereof. The basin boundary, above its southernmost extremity at the mouth of Delaware Bay, encompasses 2,362 square miles in southeastern New York, 6,422 square miles in eastern Pennsylvania, 2,969 square miles in western New Jersey, 1,004 square miles in Delaware, 8 square miles in the northeastern corner of Maryland and 782 square miles of water surface in Delaware Bay. The total area of the basin, exclusive of Delaware Bay, is 12,765 square miles. A map of the basin is shown on plate 1, bound at the end of the text.

24. NATURAL CHARACTERISTICS. The basin lies across five of the major physiographic provinces of eastern United States. These provinces, discussed in detail in appendix N, are: (a) the Catskill Mountains and southern New York section of the Appalachian Plateaus Province; (b) the Great Valley and the valleys and ridges north of Blue Mountain of the Valley and Ridge Province; (c) the Reading prong of the New England Province; (d) the Piedmont Upland and Piedmont Lowland sections of the Piedmont Province and (e) the Coastal Plain Province. The natural characteristics of the basin including geology, soils, vegetation, ground water, regimen of streams and runoff lend themselves to three general physiographic definitions, namely, the Upper Region, the Central Region and the Lower Region.

25. Upper Region. The approximate upper one-third of the Delaware River Basin extends southward to the Valley and Ridge physiographic province at Stroudsburg, Pennsylvania. It includes the southern Catskill Mountains in New York and the Pocono Mountains in Pennsylvania, and is a rugged highland of great natural beauty. Geologically, it is part of that area above Trenton, New Jersey termed the "hard-rock area". Here, as contrasted with the "soft-rock" area below the Fall Line, bedrock is resistant to erosion.

26. The Catskill and Pocono Mountains, the dominating physiographic features of this region, differ chiefly in altitude and relief. Slide Mountain on the eastern border of the basin, in the Catskills, reaches an elevation of 4,200 feet, while few summits exceed 2,000 feet in the Poconos. The region exhibits the characteristics of a plateau of flat-lying rocks that have been carved deeply by the tributaries of the Delaware River. All but the southwestern corner of the area has been

glaciated and the narrow valleys and several scenic gorges are filled with deep deposits of glacial debris. Ground water occurs in both the consolidated rocks and in the unconsolidated glacial deposits and recent sediments. The latter have the most productive wells, but the greatest amount of water is available in the consolidated rocks due to their extent.

27. The Upper Region is largely forested, and is included in the northern hardwood section as defined in appendix K. North of a line extending east and west at the latitude of Stroudsburg, Pennsylvania, the forest stands are good and the productive potential is high. About 45 percent of this area is covered with the beach, birch and maple species. These represent the most valuable timber types of the basin and are potentially the most productive. The remainder of the region is covered with mixed hardwood species, soft woods and oak-hickory stands. These have somewhat lower potential productiveness. Included also in the upper Region is the anthracite forest section, which lies south of the above described area and north of Blue Mountain. Nearly three-quarters of this area is forested, the pricipal timber types being oak-hickory, with a small mixture of softwoods, and mixed hardwood-softwood types. About one-fifth of the area is in scrub oak and aspen-grey birch types.

28. Central Region. The Central Region is geologically within the "hard-rock" area discussed above. Rock formations are old, ranging in age from 150 million years to perhaps a billion years and have been folded, faulted, thrust up into high mountains then worn down into lowlands, and encroached upon by ancient seas. This process has been repeated again and again. The rocks are the most varied in the basin and include igneous, sedimentary and metamorphic types. Only the northeastern portion of the area has been glaciated. The region is most clearly marked at its lower boundary by the Fall Line, where there is a conspicuous drop of about 250 to 350 feet in elevation to the Atlantic Coastal Plain. The Fall Line is distinctly marked by a prominent line of wooded hills. It forms an irregular stream-notched, south-facing escarpment between the undulating plateau and the Coastal Plain. The upper limits of the Central Region are less distinctly defined, depending upon the particular feature under consideration; however, this limit may be considered as the Valley and Ridge physiographic province. There it is characterized by a series of high parallel ridges, separated by narrow valleys which are orientated in a general northeast-southwest direction. These change to rolling hills and irregular ridges in the Piedmont Province and finally to the more gently undulating terrain and broad valleys in the lower portion of the area. Important physiographic features include the Blue Mountain-Kittatinny Mountain ridge; the Great Valley, which is about 8 to 20 miles in width and extends northeast-southwest across the basin; and the Reading Prong, a moderately rugged southwest extension of the New England physiographic province. The Reading Prong rises 500 to 1,000 feet above the valleys and crosses the width of the basin at the lower edge of the Great Valley.

Ground-water supplies in the Central Region vary locally depending on the geology. Some limestone and sandstone areas produce fair to large yields to wells and are the best sources of ground water in the area. The Central Region contains some of the rich soils of the country and supports an important agriculture in such counties as Lehigh, Chester, Berks and Bucks in Pennsylvania. These soils and their use and productiveness are treated in detail in appendix K to this report. Approximately 35 percent of the Central Region is in woodland and mainly in small wood lots. The forest type is principally oak but a considerable acreage of eastern cedar has come in on abandoned pasture lands.

29. Lower Region. The Lower Region extends southeastward from the Fall Line to the Capes of Delaware Bay. Geologically this area of "soft-rocks" is much younger and of simpler structure than the "hard-rock" area. The beds of unconsolidated to semi-consolidated clay, silt, sand and gravel of the Coastal Plain lie one upon another. They overlap to form a great wedge that thickens from almost nothing at the Fall Line to more than 6,000 feet at the Capes. Very large quantities of fresh water are contained in these sediments which are the greatest source of ground water in the basin. Beneath this thick wedge of soft rock is the "hard-rock" floor that is composed of the same type of rocks as those exposed above the Fall Line. Physiographically the Lower Region is the emerged part of the Coastal Plain, a gently sloping surface that extends 125 to 175 miles southeasterly from the Fall Line to the edge of the Continental Shelf. The sea inundates the outer part of the Plain and drowns the lower reaches of the streams, thus forming bays, estuaries and tidal marshes.

30. The Delaware Bay and estuary, the most important natural feature of the Lower Region, have been formed by a continuing sea-level rise, amounting to about 150 feet in the last 10,000 years. Soils of the Coastal Plain are divided into two types. Those nearest the Fall Line are generally more fertile and productive than those of the seaward area. The latter, because of their sandier composition, can retain less soil moisture. Production of farm produce is important in the use of Coastal Plain soils.

31. About one-third of the Lower Region is wooded, particularly in those areas where the soils are too wet or too dry for farming. About one-half is in softwood types (pitch, Virginia, shortleaf and loblolly pines) and mixed pine and ash. The remaining part is primarily in oak with pine and pine-oak mixtures found in the southern part.

32. RIVER AND TRIBUTARIES. Originating at small springs and seeps on the western slopes of the Catskill Mountains in New York at altitudes of about 2,500 to 3,000 feet, the West Branch Delaware River and East Branch Delaware River, flow southwesterly to form the main stem of Delaware River at Hancock, New York. From this point southeastward to Port

Jervis, New York, the river forms the boundary between Pennsylvania and New York, crossing the nearly flat, glacially scoured rocks of the Appalachian plateaus, and emerging into the Valley and Ridge Province at an elevation of about 420 feet Between Hancock and Port Jervis, the Delaware is joined by the Lackawaxen and Mongaup Rivers. At Port Jervis the Delaware turns abruptly to the southwest to be joined by the Neversink River and to flow in a narrow valley between the Shawangunk Mountains on the east and the abrupt escarpment of the Appalachian Plateau on the west. This stretch of the river forms a portion of the boundary between New Jersey and Pennsylvania.

33. At Stroudsburg, Pennsylvania, the river turns sharply to the southeast and cuts through the Blue Mountain-Kittatinny Mountain ridge at Delaware Water Gap. Above the Gap it is joined by such tributaries as Bush Kill and Brodhead Creek on the Pennsylvania side, and Flat Brook on the New Jersey side. Between Delaware Water Gap and Trenton the river also forms a portion of the boundary between New Jersey and Pennsylvania. Lehigh River enters the Delaware from the west at Easton, Pennsylvania. The drainage from the east is collected by such streams in New Jersey as Paulins Kill, Beaver Brook and Pequest and Musconetcong Rivers.

34. The character of the river changes at Trenton, New Jersey where the river flows over a series of rock ledges at the Fall Line and enters the tidal estuary. At Trenton the river leaves the "hard rock" part of the basin, turns southwestward along the Fall Line and follows the contact between hard and soft rocks downstream to Wilmington, Delaware. In this reach, the Delaware River is joined by the Schuylkill River from the west at Philadelphia and by the Christina River at Wilmington, Delaware. At the latter point the river turns seaward and flows entirely on Coastal Plain sediments to Liston Point where it enters Delaware Bay and finally reaches the ocean between Capes May and Henlopen. Important tributaries not mentioned above are included in table II-1, which also includes the principal drainage areas of the Delaware River system Detailed discussions of the physical characteristics of the basin are contained in appendix N.

35. CLIMATE. The Delaware River Basin is in the temperate zone and its climate is of continental origin or type. The climate along the coast and around Delaware Bay is somewhat modified by the effects of the sea. Air masses which influence the weather in this area move for the most part from the interior of North America and are modified by the influences of the Great Lakes and Appalachian Mountains. Heavy snows are not uncommon in the Upper Region of the basin, while the Lower Region receives little or no snow. Hot, humid weather is frequent in summer but hot dry weather may cause an occasional drought.

TABLE II-1

DELAWARE RIVER BASIN
PRINCIPAL TRIBUTARIES AND THEIR DRAINAGE AREAS

Tributary	Drainage Area (a) (sq.mi.)	Tributary	Drainage Area (a) (sq.mi.)
W. Br. Delaware R.	664.	Crosswicks Creek	139.
E. Br. Delaware R.	840	Neshaminy Creek	233.
Beaver Kill	298.	Rancocas Creek	342.
Willowemoc Creek	130.	Schuylkill River	1,909.
Callicoon Creek	112.	Little Schuylkill R.	137.
Lackawaxen River	601.	Maiden Creek	216.
Wallenpaupack Creek	240.	Tulpehocken Creek	218.
Shohola Creek	84.1	French Creek	71.
Mongaup River	208.	Perkiomen Creek	362.
Neversink River	346.	Skippack Creek	55.2
Bush Kill	156.	Wissahickon Creek	63.8
(Pike-Monroe Co.)		Christina River	568.
Flat Brook	65.7	White Clay Creek	162.
Brodhead Creek	287.	W.Br.Brandywine Cr.	131.
McMichaels Creek	111.	(head of Brandywine Cr.)	
Paulins Kill	177.	Brandywine Creek	329.
Pequest River	158.	E.Br.Brandywine Cr.	123.
Lehigh River	1,364.	Salem Creek	112.
Pohopoco Creek	111.		
Aquashicola Creek	79.4	Delaware Bay tributaries	
Little Lehigh Creek	188.	Cohansey River	106.
Jordan Creek	81.	Maurice River	388.
Musconetcong River	158.	Mispillion River	126.
Tohickon Creek	112.		
		Delaware River Basin, including the area draining into Delaware Bay (b)	12,765.

(a) Data shown were taken from Geological Survey Circular 190, published by U. S. Geological Survey in 1952.
(b) The water surface area of Delaware Bay, containing about 782 square miles, has been excluded from this total.

36. Comparative data on temperatures, rainfall, snowfall and runoff for the Upper, Central and Lower Regions are given in table II-2.

TABLE II-2

CLIMATOLOGICAL DATA

	Upper Region	Central Region	Lower Region
TEMPERATURE (in degrees Fahrenheit)			
Mean Annual	47.	50.	55.
Mean Monthly-January	22.8 1/	32.0 2/	33.3 3/
June	67.9 1/	74.6 2/	75.9 3/
RAINFALL (in inches)			
Mean Annual	60. to 42. 4/	50. to 42. 5/	43.
SNOWFALL (inches of accumulated depth)			
Mean Annual	60.	25.	20.
RUNOFF (average in inches on area)			
During growing season (May thru Sept.)	13. to 6. 4/	10. to 4. 5/	8. to 5. 6/
Mean Annual	42. to 20. 4/	29. to 15. 5/	20. to 15. 7/

1/ At Jeffersonville, New York
2/ At Lehigh University, Bethlehem, Pennsylvania.
3/ At Wilmington, Delaware
4/ In Catskill Mountains and areas of lesser elevation, respectively.
5/ In upper reaches of Little Schuylkill R. and lower reaches of Lehigh R., respectively.
6/ In northeastern and southwestern section of region, respectively.
7/ Along Fall Line and in areas adjacent to Delaware Bay, respectively.

CHAPTER III

ECONOMIC DEVELOPMENT

37. GEOGRAPHIC AREA OF INTEREST. The water resources with which this investigation is concerned are those within the geographic boundaries of the Delaware River Basin. However, it must be recognized that the service or market area for such products of these resources as domestic and industrial water supplies and hydroelectric power is limited only by the practical aspects of the distribution systems. Also, for recreation and other products that may be used by mobile ultimate consumers, that come to the point of production, the market may extend far beyond the basin's boundaries. The area of use for the water resources of the Delaware River Basin was defined, to a large extent, by the present usage of the basin's water including authorized diversions from the basin. These considerations required that the standard and expanded New York City metropolitan areas be included in the water service area. Also, those portions of New Jersey and Delaware that are outside the basin boundaries were included in the water service area because of their apparent eventual dependency on the basin as a source of fresh surface water. The water service area, thus defined, includes about 25,000 square miles comprising 53 counties located in Delaware, Pennsylvania, New Jersey, New York and Connecticut. These counties are grouped into eight subregions, the location and extent of which are shown on plate 2, with the following designations:

- A- New York City Metropolitan Area
- B- New York City Metropolitan Area Supplement
- C- Bethlehem-Allentown-Reading Metropolitan Area
- D- Trenton Metropolitan Area
- E- Philadelphia Metropolitan Area
- F- Wilmington Metropolitan Area
- G- Upper Basin Area
- H- Southern Basin and Coastal Area

38. The water resources of the Delaware River Basin are fundamental to the economic and social well-being of over 21 million people who live within the water service area as defined above. Surface and groundwater resources of the basin furnish about 3.5 billion gallons of water each day for use in homes, offices, factories, farms, and other institutions. The surface waters provide a living for the crabbers, oystermen and fishermen who harvest the natural crops of the lower bay and marshlands. The waters of the basin support the transportation of about 100 million tons of goods annually into and out of the ports of the Delaware River and Bay, and provide outdoor recreation from the headwaters in the Catskill Mountains to the Capes.

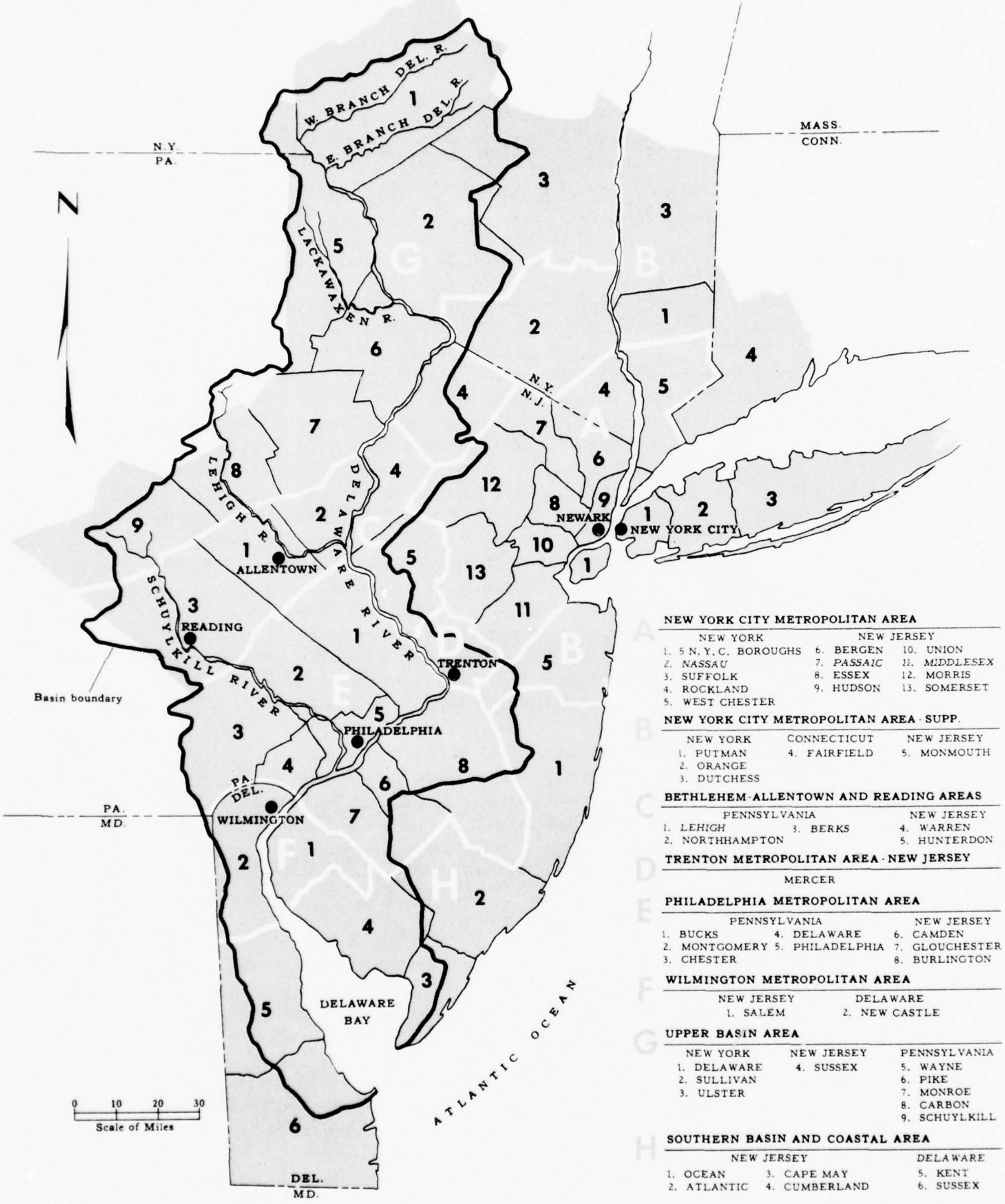


PLATE II. DELAWARE RIVER WATER SERVICE AREA - COUNTY GROUPINGS

39. Lack of control over these waters resulted in over 100 million dollars of damages to the homes, farms, factories and communities on the flood plains and the loss of 99 lives during the floods produced by Hurricane Diane in August 1955. Unregulated flows which permit excess waters to go unused to the sea have resulted in serious local water shortages as during the brief but intense drought of 1957. The efficiency of the river and its tributaries to dispose of and assimilate the waste products of the growing municipal and industrial communities is being seriously over-taxed in some areas.

40. POPULATION. The population of the service area in 1956 was 21,877,000, about 13 percent of the total continental United States population of 167,259,000. Comparing the historical growth rate of population for the service area to the national rate, it is noted that prior to 1900 population of this region grew an average annual rate of two percent per year, a rate equal to the national growth. Between 1900 and 1930, while the United States rate fell off to 1.6 percent per year, the service area's population continued to expand to an average annual rate of 2.2 percent. During the period from 1930 to 1956 the area's population growth rate fell to about 1.1 percent per year compared to a national rate of 1.2 percent during this span. This tapering off of population growth relative to the national rate in recent years reflects to a great extent the major population expansion experienced in the west. Historical data on population of the United States and Delaware River Water Service Area are shown in table III-1.

TABLE III-1

DELAWARE RIVER WATER SERVICE AREA
POPULATION GROWTH RELATIVE TO THE UNITED STATES

Year	Population (Thousands) Continental U.S.	Population (Thousands) DRSA	Average Annual % Growth per Period Continental U.S.	Average Annual % Growth per Period DRSA	DRSA as % of U.S. Total
1870	39,818	4,498	-	-	11.30
1880	50,156	5,495	2.34	2.03	10.96
1890	62,948	6,852	2.30	2.22	10.89
1900	75,995	8,737	1.90	2.46	11.50
1910	91,972	11,424	1.92	2.72	12.42
1920	105,711	13,555	1.40	1.73	12.82
1930	122,775	16,705	1.50	2.11	13.61
1940	131,669	17,715	.70	.58	13.45
1950	150,697	19,811	1.36	1.12	13.15
1955	164,303	21,589	1.74	1.73	13.14
1956	167,259	21,877	1.80	1.33	13.08

41. Population growth since 1930, within five of the eight economic subregions ranging in average from 0.8 to 1.4 percent per year, generally

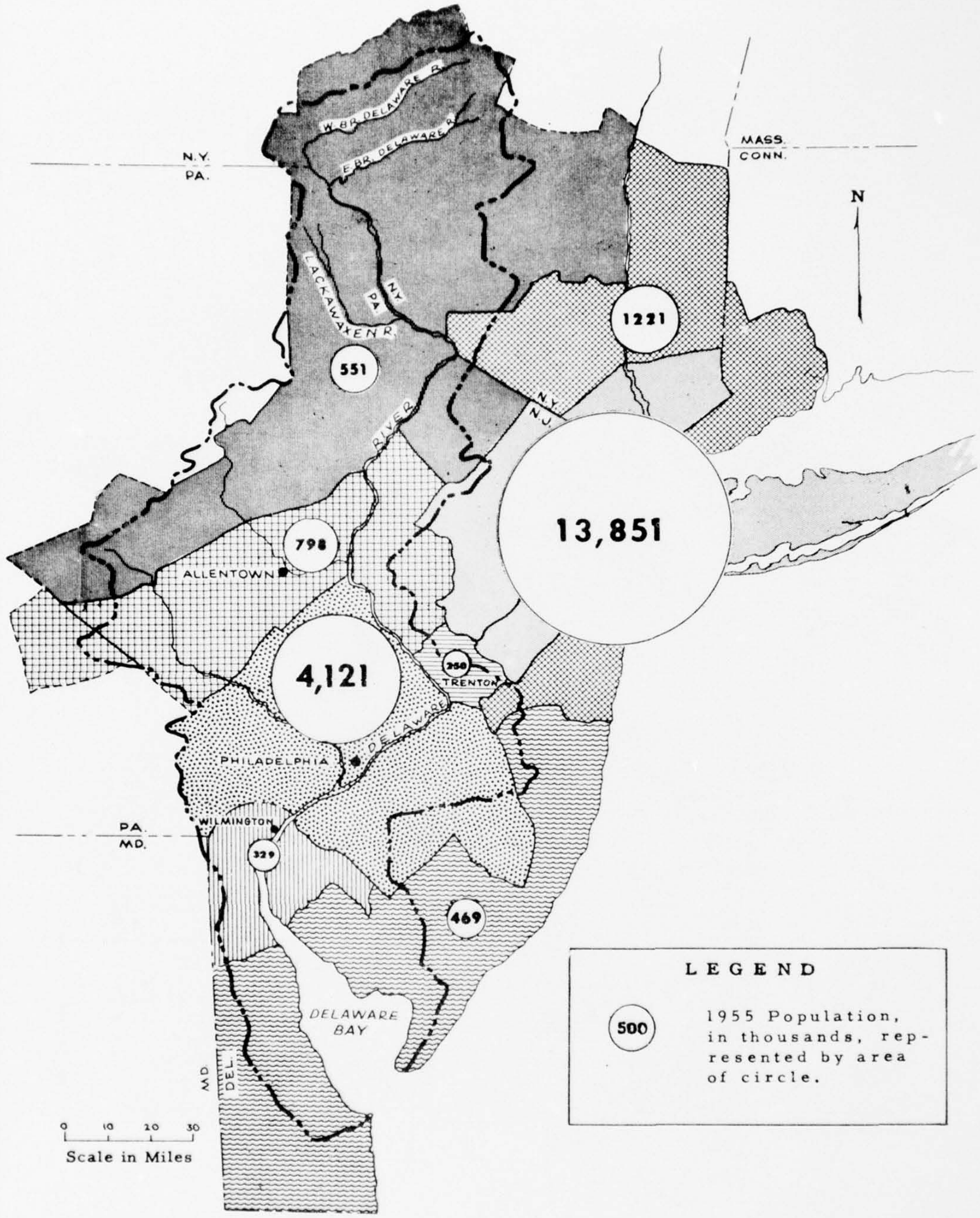
is similar to population expansion for the service area and the nation as a whole. Notable increases have been recorded in the New York City Metropolitan Supplement Area and the Wilmington Metropolitan Area which have, over the past 25 years, shown annual growth rates of 1.8 and 2.1 percent, respectively. The Upper Basin subregion's approximate population stability since 1930 reveals that population migration from this area offset any natural increase that occurred. Historical data on population and growth rates for the service area subregions are shown in table III-2.

TABLE III-2

DELAWARE RIVER WATER SERVICE AREA
POPULATION BY SUBREGIONS, 1930-1955
(Thousands)

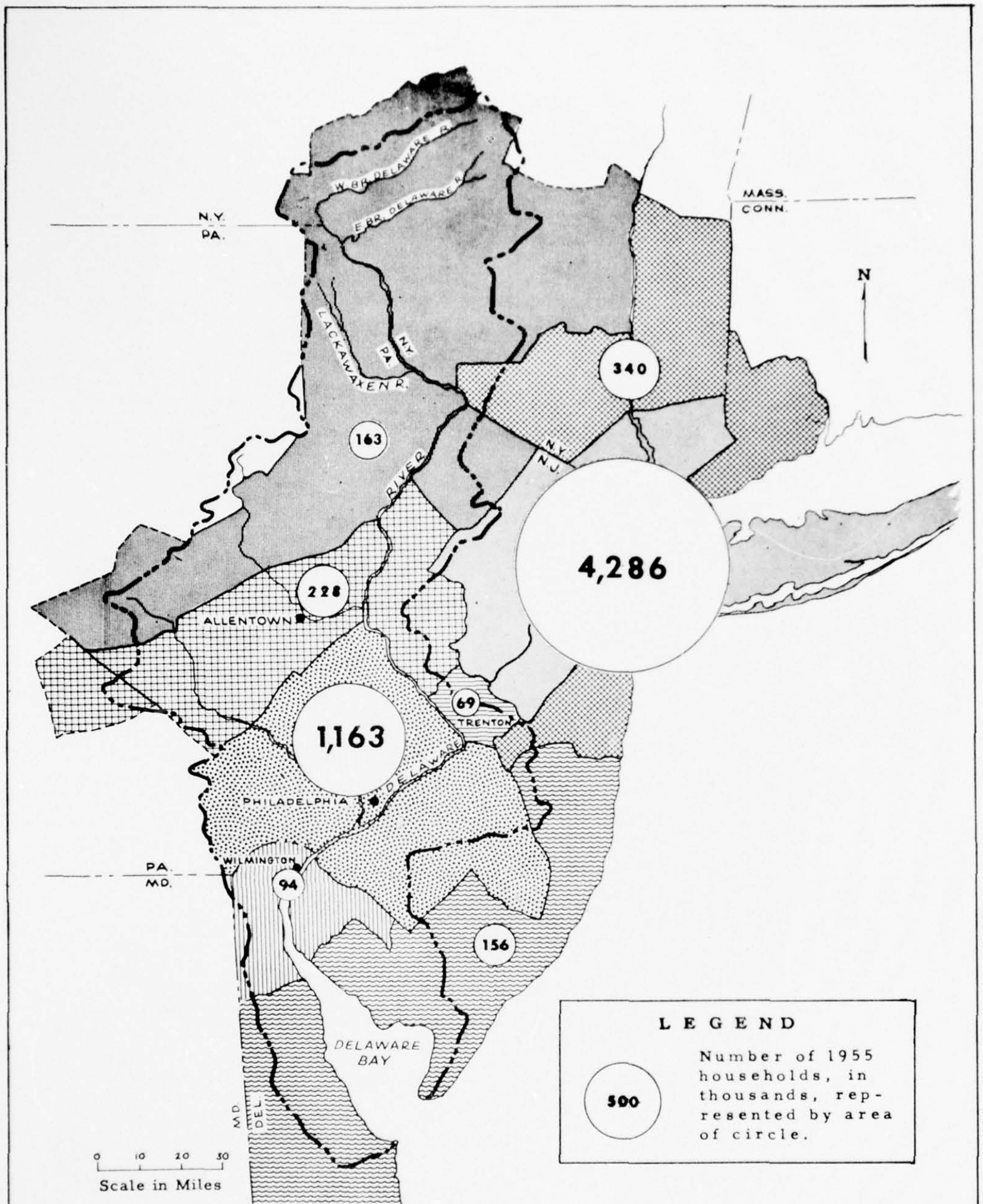
Area	1930	1940	1950	1955	Average Annual % Growth for Period 1930-1955
Continental U. S.	122,775	131,669	150,697	164,303	1.2
Delaware River Water Service Area	16,705	17,715	19,811	21,589	1.1
New York City Met.	10,859	11,661	12,912	13,851	1.0
New York City Suppl.	783	857	1,039	1,221	1.8
Bethlehem-Allentown-Reading	658	675	736	798	0.8
Trenton Met.	187	197	230	250	1.3
Philadelphia Met.	3,137	3,200	3,671	4,121	1.1
Wilmington Met.	198	222	268	329	2.1
Upper Basin	547	553	541	551	Less than 0.1
S.Basin & Coastal	335	351	414	469	1.4

By 1955 the two New York City Areas accounted for about 70 percent of the total regional population while the Philadelphia Metropolitan Area accounted for 19 percent of the total, leaving only 11 percent of the service area population distributed to the remaining five subregions. The geographic distribution of the 1955 population by subregions is shown graphically on plate 3. The geographic distribution of population is closely reflected in the distribution of households as shown on plate 4.



DISTRIBUTION OF 1955 POPULATION BY SUBREGIONS

PLATE 3



DISTRIBUTION OF 1955
HOUSEHOLDS BY SUBREGIONS

PLATE 4

42. EMPLOYMENT. Total industrial employment for the water service area in 1955 was 9,073,000, or about 14 percent of the total national employment, excluding armed forces overseas, of 65,250,000. The employment growth pattern for the area since 1900, as compared to the national growth pattern, exhibits a similarity to the comparison of Delaware River Water Service Area population growth to the United States population expansion. Between 1900 and 1930 total industrial employment in the region increased almost 100 percent, while that for the United States increased only 67 percent. From 1930 to 1955 service area employment rose 24 percent compared to the overall national increase of 34 percent. The percent increase differential, noted in the above comparisons, generally indicated that the major share of industrialization in the service area occurred during the first quarter of the century. The lower rate of industrial employment expansion since 1930, relative to the nation, reflects the rapid industrialization of newer and less developed areas outside of this region.

43. Comparison of industrial employment growth of service area with that of the nation for selected industry groups over the past 25 years, shows that industrial growth was quite general among all major industries. Historical data on employment in major industry groups for the United States and the service area are shown in table III-3. The 32 percent increase in total manufacturing employment for the service area since 1930 exceeds any other increase registered for the other industrial groups. Of singular significance has been the expansion of employment in four major water using manufacturing industries, namely, food, chemicals, primary metals and paper. Between 1930 and 1955 combined employment in these industries rose 85 percent as compared to an increase of 76 percent in these industries for the nation. Employment in these selected manufacturing industries is shown in table III-4 and the geographic distribution for 1955 is shown by subregions on plate 5. The employment in the petroleum industry, a major water-user, together with the total employment in the four manufacturing industries enumerated above, constituted 24 percent of the total manufacturing employment in the service area for 1955.

TABLE III-3

UNITED STATES AND DELAWARE RIVER WATER SERVICE AREA
EMPLOYMENT IN MAJOR INDUSTRY GROUPS
1900, 1930 and 1955
(Millions)

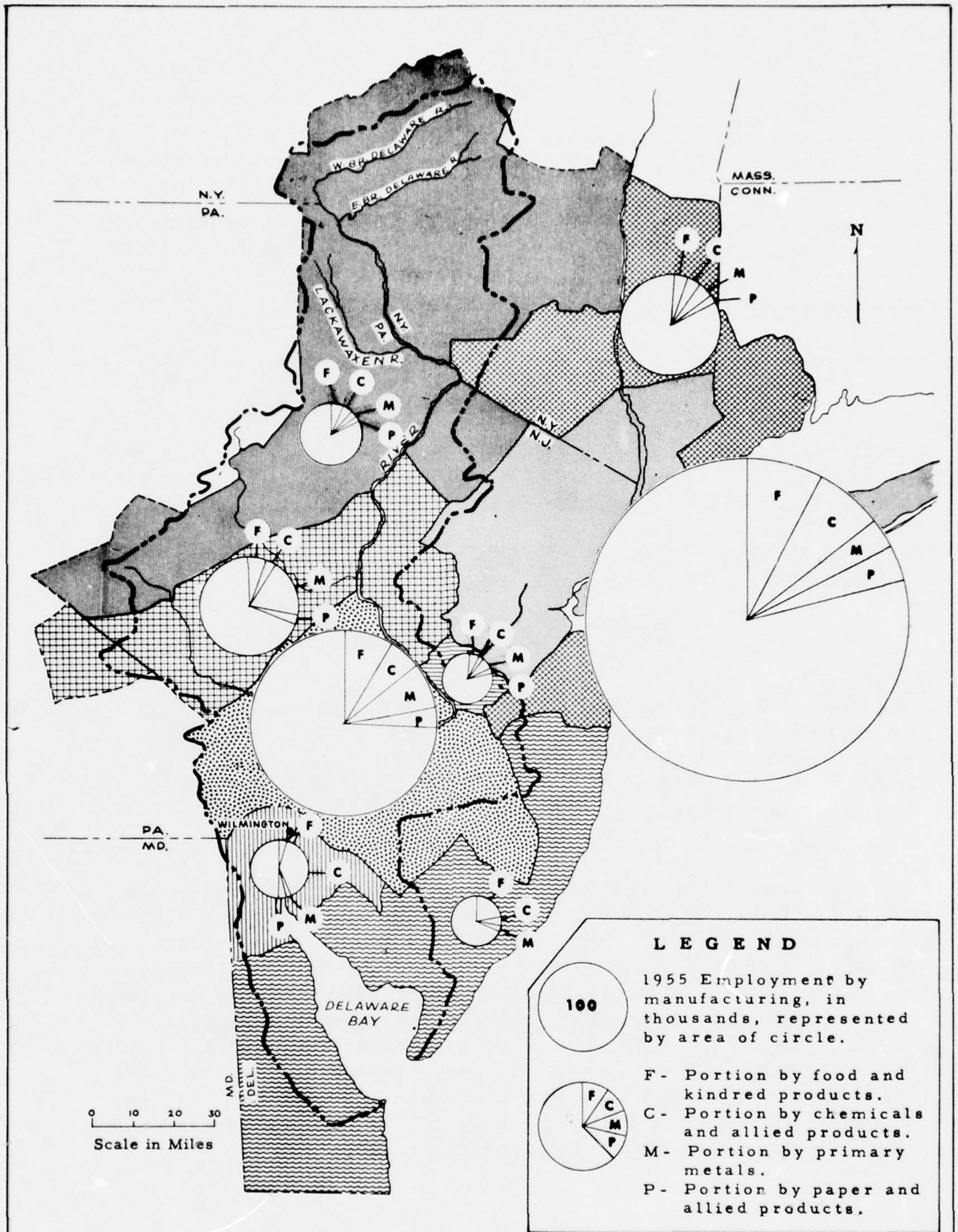
	Employment 1900	Employment 1930	1930 as % of 1900	Employment 1955	1955 as % of 1930
UNITED STATES					
All Industries, Total	29.29	48.83	166.7	65.25	133.6
All Commodity Producing Industries	17.63	26.42	149.9	29.17	110.4
All Noncommodity Producing Industries	11.66	22.41	192.2	36.08	161.0
All Industries, except Agriculture, Forestry, and Fishing	18.77	38.08	202.8	58.39	153.3
Commodity Producing	7.11	15.67	220.3	22.31	142.4
Noncommodity Producing	11.66	22.41	192.2	36.08	161.0
Manufacturing Industry	-	11.50	-	17.12	148.9
DELAWARE RIVER WATER SERVICE AREA					
All Industries, Total	3.71	7.31	196.8	9.07	124.1
All Commodity Producing Industries	1.65	3.09	187.1	3.64	117.8
All Noncommodity Producing Industries	2.07	4.22	204.5	5.43	128.7
All Industries, except Agriculture, Forestry and Fishing	3.46	7.10	205.2	8.92	125.6
Commodity Producing	1.40	2.88	206.0	3.50	121.5
Noncommodity Producing	2.07	4.22	204.5	5.43	128.7
Manufacturing Industry	-	2.20	-	2.91	132.3

TABLE III-4

UNITED STATES AND DELAWARE RIVER WATER SERVICE AREA
EMPLOYMENT IN SELECTED MANUFACTURING INDUSTRIES
1930 and 1955
(Thousands)

	1930	1955	1955 as % of 1930
UNITED STATES			
Manufacturing Total	11,498	17,121	148.9
Food and kindred products	907	1,531	168.8
Chemicals and allied products	621	804	129.4
Primary metals	627	1,329	212.0
Paper and allied products	243	554	228.0
Four-Industry Total	2,398	4,218	175.9
DELAWARE RIVER WATER SERVICE AREA			
Manufacturing Total	2,197	2,907	132.3
Food and kindred products	135	215	159.2
Chemicals and allied products	102	190	186.3
Primary metals	67	146	217.9
Paper and allied products	38	80	210.5
Four-Industry Total	342	631	184.5

44. Industrial employment between 1930 and 1955 increased most rapidly in the Wilmington Metropolitan Area where an increase of 62 percent occurred. The increase was least in the Upper Basin subregion, where it was only six percent. A check on the industrial pattern in the entire Delaware River Water Service Area reveals that almost 60 percent of all employees were engaged in service-type, or noncommodity producing industries; about 39 percent in non-agricultural commodity producing industries; and less than two percent in agricultural industries, including those employed in forestry and fishing. Data on the regional employment pattern for the service area are shown in table III-5.



DISTRIBUTION OF 1955 EMPLOYMENT BY MANUFACTURERS BY SUBREGIONS

PLATE 5

TABLE III-5

REGIONAL EMPLOYMENT PATTERNS, 1930 and 1955

Area	Percent of Total Employment in Each Area								
	Agricultural Industries 1/		Non-agricultural Commodity Producing				Noncommodity Producing		All Industries
			Manufacturing		Other				
	1930	1955	1930	1955	1930	1955	1930	1955	
United States	21.4	10.3	23.6	26.2	9.1	8.2	45.9	55.3	100
Delaware River Water Service Area	2.8	1.6	30.1	32.0	9.3	6.6	57.8	59.8	100
New York City Met.	1.0	0.5	28.3	30.0	8.8	5.6	61.9	63.9	100
New York City Supp.	8.2	3.8	31.8	34.1	8.1	8.9	51.9	53.2	100
Bethlehem-Allentown-Reading	8.3	4.7	43.2	47.9	8.3	7.1	40.2	40.3	100
Trenton Met.	3.9	1.8	36.4	33.6	9.0	8.2	50.7	56.4	100
Philadelphia Met.	3.3	1.6	35.7	36.2	8.7	7.5	52.3	54.7	100
Wilmington Met.	9.5	3.7	35.7	37.5	8.4	8.8	46.4	50.0	100
Upper Basin	14.4	9.8	19.3	31.8	28.7	12.6	37.6	45.8	100
Southern Basin and Coastal	17.1	10.9	17.1	20.2	11.5	11.9	54.3	57.0	100

1/ Includes agriculture, forestry and fishing employment.

45. NATURAL RESOURCES. The early economic history of the Delaware Basin shows that exploitation of the region's natural resources played a major role in its manufacturing and commercial growth. The lands along the Delaware River were farmed as early as 1660 by the Swedes who produced cereals, vegetables and fruits. The Delaware River, along with the Hudson and Connecticut Rivers, formed the natural highways for the early settlers. White pine, fir, and oak timber, as well as pitch pine for tar and turpentine, gave rise to the development of shipbuilding second only to New England. Manufacturing began in the weaving shops in such towns as Philadelphia following the Revolution. Iron production was greatly expanded to meet the needs of the growing post-revolution population. Major deposits of bog iron from New Jersey's southern coastal plain provided raw material for the many forges in operation during these early years. In the early 1800's the use of anthracite, found in the Lehigh Valley and the Schuylkill Valley, greatly increased the production of iron, but suitable means were lacking to transport the coal from northeastern Penneylvania to the iron mills. This problem was resolved by the construction of a number of canals during that period. The principal canals constructed were the Delaware and Hudson Canal, from Honesdale, Pennsylvania to the Delaware and Hudson Rivers; the Lehigh Canal, from White Haven and Jim Thorpe (formerly Mauch Chunk) to the Delaware River at Easton, Pennsylvania; the Delaware Division Canal from Easton to Bristol, Pennsylvania; the Schuylkill Canal from Port Clinton, Pennsylvania to Philadelphia; the Morris Canal from the Delaware River near Phillipsburg, New Jersey to Jersey City; and the Delaware and Raritan Canal from Bordentown, New Jersey, to the Raritan River. By 1825 coal had replaced wood as fuel in a large number of homes in both Philadelphia and New York. During this period western agriculture began to compete favorably with that of the east, and the movement of rural populations to urban centers in the Delaware Basin area accentuated the growing importance of its manufacturing and trade. Development of water power for mills in this area contributed significantly to its industrial growth. Water power, however, soon gave way to steam power, and more and more factories sprang up in the larger cities. Steam pumps were used as early as 1799 to raise water from the Schuylkill River to a reservoir to provide portions of Philadelphia with one of the nation's first water supply systems. The opening of the Fairmount Waterworks in 1822 supplied water to the entire city of Philadelphia.

46. The importance of local natural resources to this region steadily declined after the Civil War, due to the rapid expansion of rail transportation; the rapid growth of industrialization; and the overall development of the abundant resources of the west. By 1955 employment in the natural resource industries, such as mining, forestry, fishing and agriculture, accounted for less than two percent of the total industrial employment of the water service area.

Water, as a natural resource, continued to be a major requirement for development of the area and its importance is discussed in Chapter V. Although the present economy of the region is not primarily dependent upon its natural resources, these have served as the catalyst to expand its population and industrial activity during its early economic history.

47. MANUFACTURING ACTIVITY IN THE DELAWARE RIVER BASIN. The manufacturing activity in the basin proper is largely concentrated in the Bethlehem-Allentown-Reading, the Trenton, the Philadelphia, and the Wilmington subregions. Where available the data below are given for manufacturing activity in the basin proper. For a complete picture the available data for the basin were supplemented by data for the entire Delaware River Water Service Area as indicated below. The industrial areas are characterized by a high degree of industrial diversification with 12 leading manufacturing groups employing about 84 percent of the manufacturing labor force in these four subregions and contributing about the same percentage of manufactured value. Each of these groups employs less than 11 percent of the manufacturing labor force and contributes less than 11 percent to the value added by manufacture. The percentages of employment and of value added by manufacture are shown in table III-6 for the year 1954. Five of these industry groups are the principal users of industrial water in the Delaware River Basin. These are: paper and allied products; chemicals and allied products; petroleum and coal products; primary metals industries; and food and kindred products. These five groups employed about 28 percent of the industrial labor force in the four subregions in 1954 and contributed over 35 percent of the value added by manufacturing. These basic industries not only contribute heavily to the economic well-being of this region but are also equally significant in their overall contribution to the national economy.

TABLE III-6

DELAWARE RIVER WATER SERVICE AREA
ECONOMIC SUBREGIONS C*, D, E, F
RELATIVE CONTRIBUTION BY MAJOR MANUFACTURING INDUSTRY GROUPS
1954

Manufacturing Industry	% of Total Number of Employees	% of Total Value Added by Manufacture
All Industry Groups	100.0	100.0
Apparel and related products	10.6	5.8
Textile mill products	9.4	6.4
Machinery, except electrical	8.7	6.7
Fabricated metal products	8.5	8.5
Food and kindred products	8.4	9.1
Primary metals industries	8.3	8.6
Electrical machinery	8.0	8.6
Transportation equipment	6.6	6.6
Chemicals and products	5.8	10.4
Pulp, paper and products	3.3	3.9
Stone, clay and glass products	3.3	3.7
Petroleum and coal products	2.5	3.5
All other	16.6	16.2

* Hunterdon County, N. J., excluded
Source: Census of Manufacture, 1954, U. S. Bureau of the Census.

48. The four subregions, comprising essentially the Delaware River Basin, contain about 4 percent of the nation's paper and board source with about 30 percent of this located in the Container Corporation mill in Philadelphia and in the Scott Paper Company mill in Chester, Pennsylvania. The pulp, paper and paper-product mills in the basin contribute over $200 million of value added by manufacture or about 5 percent of that for the nation in 1954.

49. The chemical industry employs about 190,000 persons in the service area or about 24 percent of the total employment in this industry throughout the United States. Large concentrations of this industry are located in the Philadelphia and Wilmington subregions. Employment in this industry in the latter subregion constitutes about 40 percent of the manufacturing employees in that area. Chemical plants in the Delaware River Basin contributed over $580 million of manufactured value in 1954, or about 6 percent of the national value added by manufacture by this industry.

50. Petroleum refining and cracking plants in the Delaware River Basin provide about 10 percent of the national capacity in this industry. This capacity is essentially concentrated in seven refineries, all located along the lower Delaware River in the 40-mile reach between Delaware City, Delaware and Philadelphia. In 1954 these plants employed only about 2.5 percent of industrial employees in the four subregions of the basin but added about $190 million by manufacture or about 8 percent of the national value.

51. The primary metals industry in the service area employed about 150,000 persons in 1955, or about 11 percent of the total employment in this industry in the United States. About two-thirds of this employment was in the Bethlehem-Allentown-Reading and the Philadelphia subregions, where the Bethlehem Steel Company at Bethlehem, Pennsylvania, and the United States Steel Corporation's Fairless Works at Morrisville, Pennsylvania, provide about 60 percent of the steel ingot capacity of the basin. The total ingot capacity of the Delaware River Basin represents about 7 percent of the national capacity, and the added manufactured value was about $480 million in 1954.

52. About 14 percent of the national industrial employment in the food and kindred products group was located in the Delaware River Service Area with about two-thirds of it in the New York Metropolitan Area, and about one-fourth in the Philadelphia Area. The manufactured value added was about $507 million, or about 4 percent of that of the nation in 1954.

53. <u>PERSONAL INCOME AND THE ECONOMIC GROWTH</u>. By 1955, the last year for which employment and population estimates are available on an area basis, the 21-1/2 million residents of the water service area provided a labor force of 9 million people and received $51 billion of personal income. By 1957 aggregate income had increased to nearly $58 billion, an advance of almost $7 billion in two years. On the basis of a per capita total this amounted to $2,600, a figure one-fourth higher than that for the nation as a whole. Between 1929 and 1957 total personal income for the service area grew at an average annual rate of 2.0 percent which was two-thirds of the national rate of 3.1 percent. Over this period per capita personal income has been consistently well above the national average, indicating the high level of economic well-being that has been achieved in this region. The relative significance of major economic activities in terms of their over-all contribution to total personal income in 1929 and 1957 is shown in table III-7. The geographic distribution of the 1957 civilian earnings by industry, is shown on plate 6 together with the portions thereof derived from manufacturing.

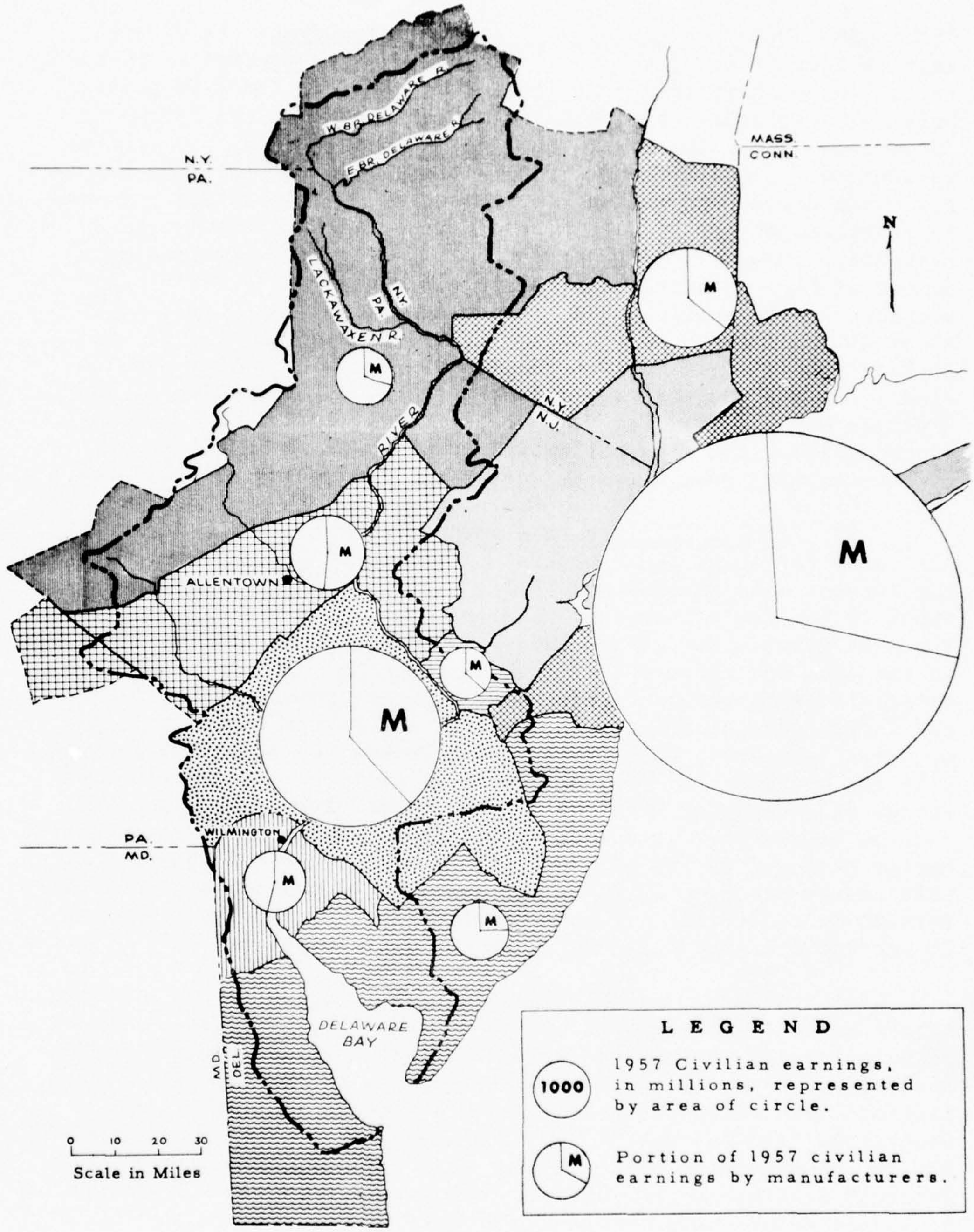
TABLE III-7

DELAWARE RIVER WATER SERVICE AREA
DISTRIBUTION OF PERSONAL INCOME BY SOURCE
1929 and 1957

Source	Percent of Total 1929	1957
Personal Income Total	100.0	100.0
Property Income	29.9	14.7
Transfer Payments	1.4	5.0
Civilian Earning Total	68.7	80.3
Manufacturing	19.7	26.1
Wholesale and Retail Trade	15.1	17.0
Services	11.3	11.8
Public Utilities, Transportation, Communications	6.9	6.8
Finance	5.8	5.4
Construction	4.7	4.7
Government	3.8	7.5
Farms	.9	.6
Mining	.4	.2
Other	.1	.1

54. Personal income and manufacturing. Manufacturing in the Delaware River Service Area is the leading economic activity of the region. It required about 32 percent of the regional employment and accounted for 26 percent of regional personal income. The service area in 1943 contained over 23 percent of the nation's manufacturing establishments and contributed over 17 percent of the total value added by manufacture in the country as a whole. The relative growth of manufacturing from 1929 to 1957 is best illustrated by comparison of its contribution to personal income, with the income from property and investments. In 1929 manufacturing contributed only about 20 percent of total personal income, while property contributed about 30 percent. In 1957, due to the growth of manufacturing in the Delaware River Water Service Area, its earnings contributed 26 percent to the total, while property income contributed only 15 percent. Over this period factory earnings increased more than three times as compared with an increase of 1-1/2 times for nonmanufacturing earnings.

55. Personal income and wholesale and retail trade. The next most important industrial sources of the civilian earnings portion of personal income are wholesale and retail trade. In 1929 these industries contributed 15 percent to the total personal income and 17 percent in 1957. In 1954 over 20 percent of the total sales recorded for all wholesale and retail trade establishments in the United States were made by the approximately 300,000 wholesale and retail establishments of the Delaware River Water Service Area.



DISTRIBUTION OF 1957 CIVILIAN EARNINGS BY SUBREGIONS

PLATE 6

56. Personal income and service industries. In 1929 the service industries of the region contributed 11 percent to personal income while their 1957 contribution amounted to about 12 percent. Service establishments in the region in 1954 accounted for about 25 percent of the total service industry receipts for the country as a whole. Closely related to the production of income in the trade and service industries are those service industries involved in recreational activities which cater to vacationists, weekend recreation seekers, and in more recent years, to an increasing number of day-visitors. Indicative of recreation's economic importance to the service area, it was estimated that people spent about $600 million for vacations in 1956 within the area of the Philadelphia District of the Federal Reserve Bank. This area includes the eastern portion of Pennsylvania, all of Delaware, and southern New Jersey. The vacation industry, including travel, produces about the same dollar volume of goods and services and employs as many people as the agricultural industry of this area.

57. Public utilities and transportation. These industries accounted for about seven percent of the total personal income in the service area in 1929 and 1957. This contribution amounted to about 17 percent of national total of these industries. These industries provide the energy needed to produce the goods manufactured in the area and the means of transporting them and their new materials from sources to markets. Electric power is supplied to the water service area by 15 electric utility companies and five municipal systems. The Federal Power Commission estimates that in 1955 the service area required about 49 billion kilowatt-hours of energy at generating stations and had a peak demand of about 10.1 million kilowatts. This represented about 9 percent of the electric energy produced in the entire United States. About 25 percent of this energy was used by rural and residential customers; about 60 percent by commercial and industrial customers; and the remaining 15 percent included all other uses and line losses.

58. A number of railroads link this region to the markets of the nation via the transcontinental and coastal routes. The principal roads include the Erie Railroad; New York Central Railroad; Susquehanna and Western Railroad; the Lehigh and New England Railroad; the Delaware, Lackawanna and Western Railroad; the Central Railroad of New Jersey; the Lehigh Valley Railroad; the Reading Company, the Baltimore and Ohio Railroad; the Pennsylvania Railroad System; and the Delaware and Hudson Railroad. A number of shallow-draft barge canals which once served the mining and industrial sections of the basin have been replaced by highway and rail transport. The Chesapeake and Delaware Canal, connecting Chesapeake Bay and Delaware River, was once a barge canal but has been converted into a ship canal and carries a large tonnage between these two waterways. The Delaware Bay and River have been improved for navigation from Trenton, New Jersey, to the sea. The tidal portions of a number of tributaries have also been improved.

59. Agriculture. While contributing less than one percent to personal income in 1957, civilian farm earnings were the only portion of personal income that increased at a rate greater than the national rate. Sales of farm products in 1954 for the Delaware River Basin amounted to over $396 million. Livestock and livestock products accounted for over 65 percent of the total, cultivated crops for 34 percent, and forest products for less than 1 percent. Sales of milk, eggs, poultry, and meat account for a larger portion of the basin's agricultural income than do all the other farm products combined.

60. Commercial fishery. In 1955 the value to fishermen of the commercial fish and shellfish harvested from waters associated with the Delaware Bay and with the economy of New Jersey and Delaware, totaled about $13.5 million. There are seven major ports of landing for commercial fishermen in the middle Atlantic area. Five of these are located on the Atlantic Coast in the vicinity of Delaware Bay and contribute to its economy.

61. Mining. Mining contributed only a small share to the personal income of the service area. In 1957 its contribution amounted to 0.2 percent. Sand, gravel, building stone, cement and anthracite are the major mineral products of the Delaware River Basin. Limited amounts of iron and zinc ores are mined, with the annual tonnage depending largely upon market conditions. In recent years sales of anthracite have sharply declined and the labor force employed in this industry has largely shifted to other industries.

62. Other sources of civilian income. Civilian earnings from finance, contract construction and Government contributed about 18 percent to the total personal income of the service area. Government contributed over a third of this and its contribution increased from 3.8 percent in 1929 to 7.5 percent in 1957.

63. ECONOMY OF THE SUBREGIONS. The economic structures of the subregions are comparatively uniform, and generally similar to that of the service area as a whole. The distribution of personal income, however, shows wide variations among the subregions. The New York Metropolitan Area accounts for 68 percent of total personal income in the Delaware River Water Service Area, the Philadelphia Area 18 percent, the other six subregions only 14 percent. The 1957 per capita personal income in 6 of the 8 subregions was higher than in most other sections of the country. Most significant were the averages for the subregions centering on Wilmington, Delaware, and New York City. The per capita income of $3,200 in the Wilmington Metropolitan subregion and $2,800 in the New York City Metropolitan subregion, exceed the national average by about one-half and one-third, respectively. In contrast are the income levels of the less populous Upper Basin Area and the Southern Basin and Coastal Area. Here per capita incomes of $1,575 and $1,875, respectively, fall short of the national average by one-fifth and one-tenth. The New York City Metropolitan Area has the

highest proportion of workers concentrated in the slower-growing service-type industries, and its manufacturing is largely concentrated in the textile and apparel industries whose expansion has been slow. The Philadelphia Metropolitan Area differs markedly from the New York City Metropolitan Area, having a smaller proportion of service-type industries and a correspondingly larger proportion of commodity-producing industries. About 49.4 percent of the employment in the six remaining subregions is in noncommodity producing industries, and 5.6 percent in agricultural industries. The Bethlehem-Allentown-Reading subregion has a greater concentration of its employment in manufacturing and in commodity producing industries than any of the other subregions.

64. In only two of the subregions are there substantial differences in income composition. The Upper Basin Area and the Southern Basin and Coastal Area are both largely agricultural, and the former contains most of the mining activity of the service area. They derive a larger percentage of labor earnings from farming than any of the other subregions or for the country as a whole.

65. DOMINANT ECONOMIC FORCES. The region associated with the water resources of the Delaware River Basin represents one of the most important regional economies in the nation. In 1955 this area, which has less than one percent of the area of Continental United States, contained about 13 percent of its population and about 14 percent of its labor force. This population has increased since 1930 at a rate of about one percent per year and employment in the same period increased at about the same rate. These rates are only slightly less than those for the nation as a whole. Industrial growth was quite general among all major industries, although at somewhat lesser rates than the growth in corresponding industries of the United States. A second significant feature of recent economic changes in this area was the differential growth of its noncommodity-producing industries, which employ roughly half again as many persons as the commodity producing ones. Manufacturing in the area registered the highest growth rate of major industry groups to maintain the service area's position of having a higher than average concentration of manufacturing.

66. Personal income in 1957 amounted to about $53 billion or 16.5 percent of that for the nation as a whole. It has increased at an average rate of about 2 percent per year compared to a national average annual rate of 2.7 percent. Aggregate earnings of persons engaged in manufacturing has replaced property income as the largest element in the personal income flow in the service area. As a source of income as well as a direct employer

of labor, manufacturing has become the largest industry in the area by a large margin. This industry is now a strongly buoyant force on overall income growth. It is believed that individual earnings from factory employment will likely tend to accelerate the pace of future economic growth in the Delaware River Water Service Area.

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CHAPTER IV

PROJECTED ECONOMY

67. INTRODUCTION. The development of the water resources of the Delaware River Basin depends largely upon the economic growth that may occur in this important segment on the national economy. The preceding chapter surveyed the present economy of this region and trends in the past growth of this economy. These trends when projected into the future provide a basis for estimating the potential expansion of the economic and the concomitant development of the water resources that will be needed in this region to sustain such expansion. Long-term trends in gross national product, population and number of households, employment, and personal income were selected as economic factors whose changes would indicate significant changes in the area's economy. Under examination in the present chapter are these factors as projected through the years 1965, 1980 and 2010. The detailed data upon which the projections in this chapter are based, as well as the methods employed in making the projections, are contained in appendices B, C, and K.

68. GROSS NATIONAL PRODUCT. The total value of all goods and services in terms of the 1957 price level produced in the national economy, or the gross national product, grew from $194 billion in 1929 to $443 billion in 1957, an increase of 128 percent. As a broad gauge of overall economic activity, the growth of gross national product has averaged three percent a year, a growth rate which has been projected in the future. Over the past three decades relative growth has been less in population and employment than in total production, indicating a sharp expansion in output for a given input of effort. This increase in productivity lies at the heart of the nation's economic progress. It has arisen from technological and managerial advances, a high rate of capital formation, expanded development of natural resources, a growing labor force and shifting of the working force into activities of high productivity. Such forces have brought an average annual advance of more than two percent in output per man-hour in the economic system as a whole.

69. On the basis of the trend described above, and conforming to the historical pattern, the gross national product is expected to rise approximately to $570 billion by 1965, $910 billion by 1980 and to $2,300 billion by 2010. Although estimates of gross regional product are not available for the service area, it is significant that the service area's projected growth is expected to expand in line with the overall economic growth of the nation as reflected in these national forecasts.

70. POPULATION. The national population is projected to rise from 174 million in 1958 to 195 million in 1965, to 248 million by 1980, and to 370 million by 2010. The population of the service area is expected to increase from 21.9 million in 1956 to 25 million in 1965, to 30 million by 1980 and to 42 million in 2010. The projected increase in population for the United States is expected to average 1.5 percent per year between 1955 and 2010. A somewhat more gradual growth, averaging 1.2 percent per year, is estimated for the Delaware River Water Service Area, reflecting the area's growth rate of recent years which was less than the national rate. With reference to the economic subregions, the Wilmington Metropolitan Area, Southern Basin and Coastal Area, the Trenton Metropolitan Area and the New York City Metropolitan Supplement Area, having experienced rapid population growth in the recent past, are projected to grow at a more rapid rate than the national average. The remaining subregions, embracing the service area's larger cities and 90 percent of the total population, are projected to grow at a somewhat lesser rate. The Upper Basin is estimated to grow at a rate well below the national average. Projections of population for the United States and the Delaware River Water Service Area, as presented in appendix B by the Department of Commerce, are shown in table IV-1.

TABLE IV-1

DELAWARE RIVER WATER SERVICE AREA
POPULATION PROJECTIONS BY SUBREGIONS, 1955-2010
(Thousands)

	Actual	Projections		
	1955	1965	1980	2010
UNITED STATES	164,303	195,000	248,000	370,000
DELAWARE RIVER WATER SERVICE AREA	21,589	25,000	30,000	42,000
New York City Metropolitan	13,851	16,000	18,500	25,000
New York City Supplement	1,221	1,500	2,000	3,400
Bethlehem-Allentown-Reading	798	900	1,100	1,550
Trenton Metropolitan	250	300	400	650
Philadelphia Metropolitan	4,121	4,800	5,800	7,900
Wilmington Metropolitan	329	450	600	1,000
Upper Basin	551	650	750	950
Southern Basin and Coastal	469	600	850	1,300

71. HOUSEHOLDS. Over the past 25 years the average number of persons per household, for both the United States and the service area, has been on a steady decline. Accordingly, the number of households has shown a greater relative rise than the total population for the United States and the service area. For the next thirty years the average size of households is expected to show little change but may decline somewhat thereafter, reflecting the expected trend in the birth rate. The number of households in the service area is expected to double by 2010. Projected trends for households for the United States and the service area are shown in table IV-2.

TABLE IV-2

DELAWARE RIVER WATER SERVICE AREA
PROJECTIONS OF THE NUMBER OF HOUSEHOLDS BY SUBREGIONS, 1955-2010
(Thousands)

	Actual	Projections		
	1955	1965	1980	2010
UNITED STATES	47,788	57,000	74,000	117,000
DELAWARE RIVER WATER SERVICE AREA	6,499	7,400	9,100	13,500
New York City Metropolitan	4,286	4,800	5,800	8,400
New York City Supplement	340	420	570	1,000
Bethlehem-Allentown-Reading	228	260	310	460
Trenton Metropolitan	69	80	110	180
Philadelphia Metropolitan	1,163	1,350	1,650	2,400
Wilmington Metropolitan	94	120	170	300
Upper Basin	163	190	220	300
Southern Basin and Coastal	156	200	280	460

72. EMPLOYMENT. National employment projections, as presented in appendix B, represent a pattern consistent with an overall annual growth rate of 3 percent for gross national product. From a base of 66 million employed in all industries in 1955, it is estimated that national employment will rise to 76 million in 1965, 97 million in 1980 and 151 million by 2010. While employment in all industries will increase 129 percent by 2010, employment in the manufacturing industries is expected to increase 150 percent over this 55-year span. The output projected in the gross national product can be achieved despite variations that may occur in both the projections of employment and population.

73. The Delaware River Water Service Area employment is projected to rise from 9 million in 1955 to about 10 million in 1965, 12 million in 1980 and to 18 million by 2010, doubling over the 55-year period. The five industries (food, chemicals, petroleum, primary metals and paper) considered as the major water-using manufacturing industries, accounted for about 19 percent of total manufacturing employment in 1955. By 2010 it is estimated that these five industries will require more than 30 percent of the projected total manufacturing employment. While the total manufacturing employment in the service area in 2010 is expected to be about twice that in 1955, employment in this five-industry grouping will be greater than 2-1/2 times the 1955 level. The most dramatic growth will be registered in the chemical and paper industries, for which it is estimated that the employment levels will more than triple by 2010. Projection of employment in the five manufacturing industries is shown in table IV-3.

TABLE IV-3

DELAWARE RIVER WATER SERVICE AREA
EMPLOYMENT PROJECTIONS BY INDUSTRIES, 1955-2010
(Thousands)

	Actual	Projections		
	1955	1965	1980	2010
ALL INDUSTRIES	9,073	10,300	12,400	18,000
MANUFACTURING	2,907	3,390	4,210	6,100
Food and kindred products	215	230	270	400
Chemicals and allied products	190	235	325	630
Petroleum and coal	65	75	90	145
Primary metal	146	180	240	400
Paper and allied products	80	100	150	300
Five-Industry Total	696	820	1,075	1,875

74. Projections of total industrial employment within the eight economic subregions of the service area reflect the pattern of industrial change that has occurred within each of the subregions since 1930. Projections of total industrial employment for each of the subregions are shown in table IV-4.

TABLE IV-4

DELAWARE RIVER WATER SERVICE AREA
EMPLOYMENT PROJECTIONS BY SUBREGIONS, 1955-2010
(Thousands)

	Actual	Projections		
	1955	1965	1980	2010
DELAWARE RIVER WATER SERVICE AREA	9,073	10,300	12,400	18,000
New York City Metropolitan	5,897	6,600	7,800	11,000
New York City Supplement	495	600	800	1,400
Bethlehem-Allentown-Reading	357	400	470	700
Trenton Metropolitan	110	130	170	280
Philadelphia Metropolitan	1,671	1,910	2,300	3,300
Wilmington Metropolitan	136	180	240	420
Upper Basin	214	240	280	380
Southern Basin and Coastal	193	240	340	540

The projection of industrial development of more than average growth for the New York City Supplement Area reflects a historical employment growth pattern considerably greater than that for the region as a whole. The projection of more rapid expansion of employment for the Trenton Metropolitan, Wilmington Metropolitan and Southern Basin and Coastal Areas, as compared to the nation, was warranted by a number of considerations involving favorable transportation facilities and the proximity of these areas to other areas of substantial industrial expansion.

75. PERSONAL INCOME. Based upon projected output, personal income for the nation in terms of the 1957 price level is expected to grow from $348 billion in 1957 to $450 billion by 1965, to $725 billion by 1980 and to $1,800 billion by 2010. During this period national per capita personal income is projected to increase to almost 2-1/2 times the 1957 estimate of $2,040.

76. The service area's growth over the most recent years has been somewhat less than for the country as a whole. This has largely been attributed to the relative degree of maturity achieved in the area during the first quarter of this century. From 1929 to 1957 total income in the region grew at an average annual rate somewhat in excess of two percent. The Office of Business Economics has indicated, in appendix B, that several forces, now present in the service area's income structure, indicate that personal income should be projected over the next 50 years at an annual rate slightly greater than 2-1/2 percent. Although slower growth has been recorded for the service area since 1929, it should be noted that in 1957 the nation and the area exhibited greater similarity in eight of the ten income sources than they did in 1929. More specifically the recent trend in the rise of manufacturing earnings as an income source and the decrease of importance of property income between 1929 and 1957, indicate a step-up in the increase of personal income over the next half century. It is further anticipated that in the more recently developed regions of the United States, outside the water service area, economic growth will begin to taper off. The differential that existed between this region and the rest of the country will become smaller over the next 25 years. Total personal income for the service area is projected to increase from $57 billion in 1957 to $70 billion by 1965 and to $100 billion by 1980. During this latter period it is assumed that expansion of personal income will begin to approximate the national growth rate and achieve a level of $224 billion by 2010. On a per capita basis the service area will continue to exhibit levels higher than the average for the nation as a whole over the projection period. It is expected that by 2010 the differential between this region's per capita personal income and that of the nation will have been reduced. Projections of personal income for the United States and for the service area are shown in table IV-5.

TABLE IV-5

DELAWARE RIVER WATER SERVICE AREA
PERSONAL INCOME PROJECTIONS BY SUBREGIONS IN CONSTANT DOLLARS
1965-2010
(billions of 1957 dollars)

	Actual	Projections		
	1957	1965	1980	2010
UNITED STATES	347.9	450.0	725.0	1,800.0
DELAWARE RIVER SERVICE AREA	57.6	70.0	100.0	224.0
New York City Metropolitan	39.3	46.7	64.4	139.0
New York City Supplement	2.9	3.8	6.2	17.0
Bethlehem-Allentown-Reading	1.8	2.2	3.3	7.8
Trenton Metropolitan	.7	.9	1.4	4.0
Philadelphia Metropolitan	10.1	12.1	17.8	39.5
Wilmington Metropolitan	1.1	1.6	2.6	7.0
Upper Basin	.9	1.2	1.8	4.0
Southern Basin and Coastal	.9	1.3	2.3	6.1

77. It is estimated that total personal income for the nation will more than quintuple between 1957 and 2010 and the income of the service area will quadruple during this period. However, in the same period, personal income in the New York City Supplement and the Trenton Metropolitan subregions will increase to more than five times that of 1957, and in the Wilmington Metropolitan and the Southern Basin and Coastal subregions it will increase to more than sixfold. The basis for these increases were already noted in the discussion of the subregion industrial employment projections.

78. PROJECTIONS OF LAND USE. Studies of land use within the basin proper, as discussed in appendices G and K, indicate that about 9 percent of the 10 million acres of land area is presently under urban development. Present land use for the Delaware River Basin is shown in table IV-6.

TABLE IV-6

DELAWARE RIVER BASIN
LAND USE PATTERN, CIRCA 1955
(Thousands of acres)

	Total Area Classified by SCS 1/	Type of Land			
		Urban		Open	
		Acres	%	Acres	%
DELAWARE RIVER BASIN	10,000	896	9.0	9,104	91.0
Bethlehem-Allentown-Reading	1,465	93	6.3	1,372	93.7
Trenton Metropolitan	150	24	16.0	126	84.0
Philadelphia Metropolitan 2/	2,165	380	17.5	1,785	82.5
Wilmington Metropolitan	445	94	21.1	351	78.9
Upper Basin 3/	3,661	189	5.2	3,472	94.8
Southern Basin and Coastal	2,114	116	5.5	1,998	94.5

1/ Each subregion includes several counties, portions of which are located outside the Delaware River watershed.

2/ Includes estimate of lands in Philadelphia County that were not included by Department of Agriculture.

3/ Includes estimates for only those portions of the counties in New York State that lie inside the Delaware River watershed.

As shown in table IV-6 urban land use and development is the greatest in the metropolitan areas of Trenton, Philadelphia and Wilmington. Based upon the appraisal contained in appendix K that additional population growth will require an additional 1/4 acre per person, it is possible to forecast the amount of non-urban land that will have to be used for future urban development. By 2010 approximately 1,800,000 acres of additional non-urban land will be needed in the basin for urban use to satisfy the needs of an expanding population. More than half of this total will be needed for the urban growth in the Philadelphia Metropolitan Area. Urban growth in the Bethlehem-Allentown-Reading, the Wilmington and the Southern Basin and Coastal Areas will require about 600,000 acres of additional land or about one-third of the total needed. About one-sixth of the total needed (about 200,000 acres) will be in the Trenton and the Upper Basin areas. Assuming that all of this land will be obtained from present non-urban lands, by 2010 about 27 percent of the total land in the basin will be under urban development. In addition, data presented in appendix I indicate that over 1.2 million acres of additional recreation lands will be required by 2010 within the service area to satisfy the demand for new recreational opportunities generated by the expanding population of the region.

79. OTHER FACTORS. Whether or not this region can achieve the high level economy projected for it over the next half century will depend upon the favorable operation of a highly complex set of factors. The historical and projected levels of economic development show that a potential for major expansion already exists within the region as well as for the country as a whole. One factor upon which the service area will rely to sustain and nourish its growth will be the reasonable exploitation of its water resources. The service area's present reliance upon its water resources and the problems associated with the development of this vital resource are discussed in subsequent chapters.

CHAPTER V

CONTRIBUTION OF WATER RESOURCES TO THE REGION'S ECONOMY

80. INTRODUCTION. A basic principle in this investigation was that the goods and services to be secured through water resources development shall have economic value only to the extent that there exists, either now or in the future, a need or demand for the several water resource products. The market for water resource derivatives arises out of the relationship existing between the water resources of the Delaware River Basin and the growth and development of the region within its zone of influence. Previous chapters have shown that the populous Delaware River Basin combined with the larger service area in which it is located, is one of the major industrial and commercial centers of the United States. The continued ability of this region to expand its activities will, to a great extent, depend upon a reasonable development and use of its water resources. This chapter describes the relationship that exists between the water resources of the basin and the continued economic growth and development of the region. The factors that limit the extent and use of these water resources in serving the needs of the region are also discussed. Lastly, the elements that were used to arrive at the balanced program for resource development for the basin are enumerated.

81. SUPPLIES OF WATER. The most elemental requirement placed on the water resources of the basin is the provision of supplies of water for domestic and municipal use. Over ten million residents of the water service area are currently withdrawing over one billion gallons of water a day from the ground and surface water sources of the basin to satisfy their needs. The high standard of living enjoyed by the people of the area associated with higher standards of health and cleanliness and with the increasing use of water-consuming home appliances has resulted in a daily use of approximately 120 gallons of water per person. As population continues to expand, with concomitant increases in living standards over the next half century, an even greater reliance must be placed on the water resources of the basin. Should the current excesses of water in the basin become scarce in the future, it is very likely that the people served from that source would either have to adjust to a restricted use of water or be forced to obtain additional supplies from other sources. A more drastic consequence of water shortage would be the migration of the people of the basin to other parts of the country where water supplies are more plentiful. While real substitutes for the water of this basin (such as desalted sea water and diversions from other basins) may be developed in the future, it appears certain that the Delaware River Basin, because of the quality of its water and its orientation with the major water demand centers, will continue to be the major source of supply for domestic and municipal purposes for the people of the basin and for sizable populations beyond its boundaries. However, since diversions from the basin are authorized by

the U. S. Supreme Court, it would be presumptive to project, for purposes of this investigation, diversions to satisfy, wholly or in part, the water needs in adjacent areas at designated dates in the future. Therefore, except for current diversions, the water uses of primary interest are those within the basins boundaries. Furthermore, this approach was supported by the fact that local water resources and their capabilities to s atisfy the water needs in the areas adjacent to the basin were beyond the scope of this investigation.

82. Water use inventories by the U. S. Public Health Service, as presented in appendix C, indicate that the industrial production processes use more than 70 percent of all water withdrawn for all purposes in the basin. The major water using industries of the basin are: food, paper, chemicals, petroleum and primary metals. They withdraw more than 540 billion gallons a year from the basin, equal to about three-fourths of the basin's total industrial water use. As indicated previously, manufacturing activity of this basin is presently, and will continue to be, the major source of civilian earnings for the people of the area, currently employing over 900,000 persons earning in excess of 4.5 billion dollars annually. The availability of water of sufficient quantity and quality is one of the major factors that will be required to permit the expansion of industrial activity as indicated in the projections of growth shown in chapter IV. Failure to provide it may result in serious economic losses both to the region and the nation, since the lack of water would restrict expansion and the full utilization of basic industrial plant and equipment.

83. The 1955 production of electric energy in the basin area by thermal plants required an estimated 3.4 billion gallons of water per day for cooling purposes. The future expansion of the basin's power production capacity requires an assured and inexpensive supply of water of tolerable quality. Should the water resources of the basin become unable to fully satisfy future cooling water requirements, increases in operating and installation costs for electric power production may result.

84. Water withdrawn for agricultural, irrigation, livestock, and rural use presently amounts to only one percent of all water presently withdrawn for use in the basin. Agriculture as an industry contributes only small amounts to both the employment and the personal income of the region. However, it produces the major share of the food products consumed in the basin and serves as an important feeder industry for the food processing plants of the area. The water needed to service this section of the economy, although small in comparison to the needs for domestic, municipal, and industrial use, nevertheless, is crucial if agriculture is to maintain its position within the region. This is especially true for the Upper and Lower Basin Areas where nearly seven percent of personal income is derived from farming.

85. WATER QUALITY AND STREAM POLLUTION. Maintenance of water quality and reduction of stream pollution are equally essential in the satisfaction of the several water supply markets discussed above. To evaluate the contribution of water quality and pollution abatement, as they relate to the overall well-being of the region, consideration has been given to the several quality requirements placed upon the waters of the basin by the quantitative water supply needs. These requirements also bear heavily on the use of streams for recreation and commercial fishing as well as on the aesthetic value of clean streams. Quality requirements may be very stringent when the water is used for domestic purposes or when used in food processing plants. Quality requirements may be substantially lower when the water is used for, say, the metals industries and cooling purposes. While quality requirements will differ from one use to another, the degree of treatment varies according to the point at which raw water withdrawals are made within the basin, and, in almost all cases, some treatment is required to bring the raw water to the quality level desired. As population and industrial activity expand in this area over the next fifty years with resultant increased waste loads for discharge to the waters of the basin, more and more attention must be directed to the contributions that can be made to the improvement of water quality and the abatement of pollution through reduction of the waste load. The sizable investment presently made in these fields and the tremendous investments to be expected in the future are indicative of the importance of such programs as they relate to the beneficial uses of water in the region. Failure to recognize future trends in water use, that may well add to the overall water quality problems of the basin, would result in preventing such investments from achieving their full contribution to the welfare of the community.

86. SALINITY CONTROL. Of particular interest to the water users in the tidal section of the Delaware River is the contribution that may be secured through the control of salinity. The salinity front, while not affecting sources of water currently being utilized for domestic supplies, continually poses treatment problems for water-using industries downstream from Eddystone in the Chester-Marcus Hook area. The control of salinity in this area could reduce the cost of chemical treatment required to remove the objectionable salinity constituents, obviate the need for additional investments in fresh water developments to offset further deterioration in the quality of the river, and mitigate the costs of water supplies for downstream areas.

87. CONTROL OF FLOOD FLOWS. Control of flood flows in the Delaware River and its tributaries would contribute to the overall well-being of this region by preventing damages to real property and the loss of goods and services. It would also make possible the increased production of goods and services through a more intensive use of real property on or adjacent to the flood plain that cannot now be utilized due to the flood hazard. The occurrence of seven

major flood-producing storms since 1900 has resulted in major losses of both life and property throughout the basin. The storms of August 1955, producing the largest flood of record generally through the basin, resulted in the loss of 99 lives and caused property damage and business losses in excess of $100 million. The continued use and redevelopment of the flood plain over the next fifty years may result in a situation wherein the potential damages from a flood of the 1955 magnitude that would exceed the damage caused by that flood by as much as one-third. Mitigation of such losses by appropriate flood control measures would permit valuable resources of land and real property to sustain, in a continuing fashion, its beneficial and productive contributions to the economy. At the same time control of flood flows would release, for use in production of new goods and services, resources that otherwise would be diverted for the purposes of repair, replacement, cleanup and other forms of emergency relief required as a result of floods. With each flooding many commercial and industrial establishments may be forced to curtail operations ranging from a few days to as much as three weeks with attendant layoff of employees and loss of production. These are real economic losses and certainly any justifiable measures to lessen or eliminate such losses are positive forces contributing to the economic and social well-being in the affected areas.

88. NAVIGATION. The improvement of the Delaware River and its tributaries for navigation contributes to the ecomomic growth of this region. Canals constructed in the early 1800's provided the first economic means of transporting coal from the Lehigh Valley and the Schuylkill Valley to the major manufacturing centers of the area. As more economical means of transportation were developed and the market for anthracite declined, these canals fell into disuse for transportation. The existing and authorized navigation projects in the tidal sections of the Delaware River and tributaries, however, continue to make positive contributions to the basin's economy. Commerce in the Philadelphia port area has quadrupled since 1920. In 1958 about 100 million short tons of cargo were moved through the ports and carried through the navigation channels of the Delaware River and tributaries from Trenton to the sea, about ten percent of the total cargo carried on all rivers, canals and connecting channels of the United States. Foreign commerce passing through the ports on the Delaware River constitutes a major portion of this total. In 1958 42 million tons of import cargo were received through these ports and 3-1/4 million tons of export cargo were shipped from the area, together accounting for 1/4 of all foreign commerce for all ports of the United States. The importance of these navigation channels to the region can best be seen by the relationship between the ports of the area and the industrial and commercial activity of the region. In the Wilmington, Philadelphia and Trenton Metropolitan Areas it has been estimated that for manufacturing alone nearly one job in every five depends upon materials brought in through the ports. Also, more than 96,000 employees of these three metropolitan areas derive their income either directly or indirectly from the Delaware River ports.

89. HYDROELECTRIC POWER. The importance of the generation and distribution of electric energy to meet the requirements of farm, residential, commercial, industrial and other consumers is well-known. Such service is essential to the continued growth and development of the region. Hydroelectric installations currently account for seven percent of the total dependable power capacity of all plants in the pertinent power marketing area as defined in Appendix F. Within the Delaware Basin installed capacity of existing hydroelectric plants is about 70,000 kilowatts. In terms of electric energy production, hydropower's contribution is small. However, in terms of the savings that may result by the installation of hydroelectric facilities as compared to alternative forms of conventional power generation, the contribution that may be made through the generation of power by this method becomes significant. Technical advantages inherent in hydropower allow its energy to be placed into the distribution system on short notice during periods of heavy demand or in emergencies without incurring additional fuel costs as would be required in the case of thermal-electric facilities. This feature makes hydropower particularly unique in its ability to satisfy some portion of the overall power demand market.

90. RECREATION. Recreation resources and facilities contribute to this region's overall economic and social well-being by providing opportunities for one-day outings, overnight outings and extended vacations to enjoy such activities as swimming, boating, picnicking, sightseeing, going to the beach, fishing, hunting, camping and visiting museums. Many of these activities can be directly related to the water resources of this basin. It has been estimated that in 1955 the 21-1/2 million residents of the service area recorded over 81 million visitor-days while participating in various outdoor recreational activities. Of these, State Park attendance, hunting, and fishing accounted for 34-, 33-, and 14 million visitor-days, respectively. As population continues to expand with continued improvement in its economic well-being and with the availability of more leisure time, it is reasonable to expect that ever increasing requirements will be placed on existing and proposed recreational facilities. The provision of new and expanded recreational opportunities will permit substantial portions of this area's population to realize the full value of increasing leisure time and improved living standards. In those portions of the region where the recreation industry is a vital force to the local economics, the expansion of recreational facilities and opportunities will be required as an element contributing to their economic growth. An indication of the economic importance of recreation to the area is the estimated $600 million spent in 1956 for vacations within the Philadelphia Federal Reserve Bank District.

91. COMMERCIAL FISHERIES. Five of the seven major ports used by commercial fishermen in the Middle Atlantic Area are located relatively close to the mouth of the Delaware Bay. The bay area produced substantial shares of the total harvest in the United States

of menhaden, oysters and clams. Lewes, Delaware, where landings of 308 million pounds of commercial fish were reported in 1955, is the third ranking fishery port in the nation. The two hundred related manufacturing and wholesaling establishments dealing with fish and fishery products located in the region employ on the average more than 5,000 persons during the fishing season and were responsible for the production of fishery products valued at about $50 million in 1955.

92. LIMITING FACTORS. In assessing the overall impact of the water resources on the region, consideration was given to the physical and economic factors that limit the ability of the water resources of this basin to produce or augment the water resource goods and services discussed above. Pertinent physical factors are the natural flow of the surface waters of the basin, the adequacy of subsurface sources, the quality of the water, the availability of suitable storage sites and the complimentary and competitive uses of water in satisfying more than one water use purpose at several points in the basin. The limiting economic factors involved here are the availability of investment funds for resource development, the alternative opportunities for optimum economic gains from these types of investments, the extent to which resource development is required to sustain and nourish the economy, and the established rules and practices encountered in resources development. The balanced program for water resources development and production of water resources goods and services therefrom for this basin had to be defined in a manner consistent with these limiting factors. While it was possible to identify individual requirements that must be placed on the water resources of the Delaware River Basin during the next fifty years, it was not possible to indicate specifically the nature of the inter-relationships that exist among the water resource products as they collectively relate to the continued growth of the area. For a balanced program of resource development, it was necessary to plan for the production of as many of these products (known to contribute to the region) as was considered economically feasible.

93. The process by which specific purposes were chosen for inclusion in the plan of development required study of the physical and economic resources available for development and the available alternative production measures not necessarily tied to the water resources of the basin that also satisfy the several water resources markets. It was recognized that although certain goods and services could be produced only through water resources development, there remained others, such as recreation and the production of electric energy, whose production could be secured through developments not normally associated with this resource. In terms of water resource production measures all levels of water control from simple land management measures to major multi-purpose impoundments have been integrated into the plan of development presented in this report. It was not practical

nor was it possible to consider that the production of all the required products could be secured in unlimited quantities through water resources control only. Thus the contribution of water resources development to the future growth of the regional economy will, necessarily, be limited.

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CHAPTER VI

DEMANDS ON WATER RESOURCES

94. MEANS FOR ASSESSING DEMANDS. The quantitative dimensions of markets for the various products of water resources development have been established through a series of examinations of past and present demands on water resources as related to the economic activities of the water service area and by broad projections of the needs for development of water resources based on anticipated economic growth. These examinations and projections were made in some cases by the Corps of Engineers, in other cases by the agency of primary concern, and in others cooperatively by two or more agencies. In all cases, however, the evaluation of demands on water resources was made to comply with the wishes of local interests as expressed at public hearings, by correspondence, through representatives on the Delaware Basin Survey Coordinating Committee, and by directive from the Congress.

95. A study of existing and planned developments for water resources in the basin showed that their most significant products and services have been water supply, hydropower, navigation, flood control and recreation. At the public hearings held at the time the comprehensive studies of the basin's water resources were initiated and at times throughout the study period, general interest was expressed in broad multiple-purpose development of the water resources. Included in the purposes to be served were flood control, water supply, hydropower, irrigation, recreation, preservation of shell and fin fisheries, increased low flows, pollution abatement, navigation and prevention of salt water intrusion. Except in the case of flood control, where a number of local problems were cited and requests made for studies of a variety of relief measures, and in the case of water supply, where a few local problem areas were identified, the requests of local interests were in broad general terms. As the study progressed it was found that while existing needs for flood control and certain types of water supplies could be pinpointed geographically with fair accuracy, future requirements for supplies of water, flood control, recreation, hydropower, et cetera, were best defined in rather broad geographic areas as indicated in the discussion of these needs in the following paragraphs.

96. SUPPLIES OF WATER FOR DOMESTIC, MUNICIPAL, INDUSTRIAL AND RURAL USES. The basin contains a complex of developments designed to satisfy the water supply needs of a multitude of specific localities or individual users. The raw waters to satisfy these needs come from surface or subsurface sources of fresh or brackish supplies. The most significant present withdrawals are made for municipal water supplies for Philadelphia and New York City. The average 1957 withdrawals for these two supplies amounted to about 352-and 365 million gallons per day (mgd), respectively. Significant present individual withdrawals

of self-supplied industrial water average about 125 mgd at Bethlehem, Pennsylvania, 255 mgd at Morrisville, Pennsylvania, and 396 mgd at Delaware City, Delaware.

97. The existing major impounding facilities designed to augment available supplies of surface water for municipal uses are shown in table VI-1.

TABLE VI-1

EXISTING MAJOR WATER SUPPLY RESERVOIRS

Reservoir	Stream	Supplies in Billion Gallons	Gross Yield in Million Gallons/Day
Cannonsville	W.Br. Delaware R.	95.5 1/	388.0
Pepacton	E.Br. Delaware R.	140.0 1/	427.0
Neversink	Neversink R.	34.9 1/	126.0
Wild Creek	Wild Creek 2/	4.1	3/
Penn Forest	Wild Creek 2/	6.5	3/
Ironworks Cr.	Neshaminy Creek	0.68	12.0
Lake Ontelaunee	Maiden Creek	4.0	77.0
Green Lane	Perkiomen Creek	4.4	16.5
Pickering	Pickering Creek	0.35	5.5
Springton	Crum Creek	3.5	16.0
Octorara	4/	3/	30.0

1/ Based on maximum depletion
2/ In Lehigh River Basin
3/ Not available
4/ On Octorara Creek in the Susquehanna River Basin with diversion to the Delaware River Basin

98. Available supplies of water are adequate to satisfy all present needs when considering the basin as a whole without reference to local problems arising from inequitable distribution of these supplies. Local interest at the hearings and in correspondence expressed the desire for general conservation and development of the water resources of the basin for domestic, municipal and industrial uses. Need was expressed for increased low flows to reduce stream pollution without reference to specific localities, to prevent salt water intrusion and to stabilize or force a downstream retreat of the salinity front that now prevails in the estuary in the vicinity of Edgemoor, Delaware under medium flow conditions. During prolonged periods of low flow, the salinity front advances to Chester, Pa., and occasionally to the mouth of the Schuylkill River. Requests for

specific developments to meet anticipated major water requirements were not forthcoming from local interests during the course of the study. However, solutions to local water problems at Tuscarora and Lansdale-North Wales area in Pennsylvania and Morris County in New Jersey were requested by local interests. In connection with these local water problems it was found that adequate supplies of suitable water to satisfy their needs are presently available at some distance from the point of need and, accordingly, these local needs were considered as imposing no specific demands on future water resource developments in the basin. The detailed engineering studies needed to determine the most practical and economical means of getting available water supplies to local distribution systems were not made as a part of this investigation. Local interests in the State of Delaware requested studies of detailed and extended scope to determine the practical aspects and economic feasibility of a salt water barrier in the Delaware River Estuary to provide a fresh water impoundment to satisfy anticipated water needs in the areas adjacent to Delaware Bay.

99. The gross water needs of the water service area were projected to selected years in the future by use of projected population and industrial growth from the Economic Base Survey in appendix B, and the application of projected trends in water use per capita and per unit of industrial activity as described in detail in appendix P. Projected gross water needs for irrigation, stock watering, and rural residences were defined by the Department of Agriculture based on indicated trends in land use and farming practices. These projections are reported in detail in appendix G. Water for cooling purposes at future thermal-electric generating facilities were considered as imposing no specific demands on developments for augmenting stream flows since the return to the stream is equivalent in quantity and quality to the withdrawals in each instance of such use. Under these conditions, and assuming proper location of future facilities with respect to available natural and modified stream flows, the specific demands on water resources development arising from this type of use would be insignificant.

100. As explained in paragraph 81, the projected water supply requirements of primary interest in this investigation are those within the basin boundaries. Although New York City has indicated a projected need for additional water supplies by year 2010, the question of satisfying this need from the Delaware River Basin or from other sources outside the basin is beyond the scope of this investigation. The assessment of stream flow augmentations required for water supply purposes in the basin was made by modifying the projected gross demands to take into account the present availability of natural minimum stream flows, minimum stream flows augmented by existing projects, the use of ground water, the use of brackish supplies where appropriate, and a conservative estimate of repetitive use of water by successive downstream users compatible with the desirability of maintaining acceptable levels

of water quality. The projected net surface water augmentations at years 1965, 1980 and 2010 are shown by use categories and geographical subareas in table VI-2. The current (1955) surface water uses, as inventoried by the U. S. Public Health Service and reported in detail in appendix C, together with projected gross and net surface water needs, are summarized by geographic subareas on plate 7. Flow augmentations to satisfy these surface water needs are indicated, also on plate 7, for key stream gaging stations in the basin.

101. REDUCTION OF FLOOD DAMAGES. The reduction of flood damages is an important service obtained from control of the water resources of the basin. Existing developments in the interest of flood control in the basin range from individual efforts for relief from flood problems at very limited local areas to major projects for alleviating community-wide flooding. Local protection works provided as municipal or community projects are located at numerous places in the basin. Typical examples of this type of project are found at Port Jervis, New York and Burlington, New Jersey. A vigorous flood protection program by the Commonwealth of Pennsylvania has resulted in major local protection projects completed or under construction at Hawley, Stroudsburg-East Stroudsburg and Weissport, Pennsylvania. Numerous channel rectification, clearing and dredging projects have been completed by the Commonwealth. Examples of projects in this latter category are those at White Mills and Greentown in the Lackawaxen River Basin. Active watershed associations have plans approved under Public Law 566

TABLE VI-2

SURFACE WATER REQUIREMENTS IN WATER PROBLEM AREAS IN THE BASIN

Use		1965	1980	2010
UPPER DELAWARE AREA				
Domestic and Municipal	(mgd)	17.3	24.0	42.9
Self-supplied Industrial	(mgd)	12.3	18.3	38.3
Agricultural	(mgd)	3.3	3.9	4.0
Total	(mgd)	32.9	46.2	85.2
Reqd.Surface Water Augmentation	(cfs)	0.0	0.0	0.0
MIDDLE DELAWARE AREA				
Domestic and Municipal	(mgd)	4.5	6.3	12.1
Self-supplied Industrial	(mgd)	29.1	43.1	94.2
Agricultural	(mgd)	Included in Trenton-Phil.		
Total	(mgd)	33.6	49.4	106.3
Reqd.Surface Water Augmentation	(cfs)	0.0	0.0	0.0
LEHIGH AREA				
Domestic and Municipal	(mgd)	41.3	58.4	108.4
Self-supplied Industrial	(mgd)	194.0	228.5	364.2
Agricultural	(mgd)	2.4	2.8	2.9
Total	(mgd)	237.7	289.8	475.5
Reqd.Surface Water Augmentation	(cfs)	48.3	129.0	416.0
UPPER SCHUYLKILL AREA				
Domestic and Municipal	(mgd)	52.5	72.9	132.7
Self-supplied Industrial	(mgd)	123.3	153.3	197.7
Agricultural	(mgd)	Included in Trenton-Phil.		
Total	(mgd)	175.8	226.2	330.4
Reqd.Surface Water Augmentation	(cfs)	0.0	56.0	217.0
TRENTON-PHILADELPHIA AREA				
Domestic and Municipal	(mgd)	583.8	812.8	1445.8
Self-supplied Industrial	(mgd)	1034.7	1141.0	1155.3
Agricultural	(mgd)	19.3	24.4	24.4
Total (Incl. surface losses)	(mgd)	1917.5	2377.6	3415.7
Reqd.Surface Water Augmentation	(cfs)	0.0	491.0	2100.0
WILMINGTON AREA				
Domestic and Municipal	(mgd)	48.2	72.0	151.4
Self-supplied Industrial	(mgd)	933.0	1549.0	2744.0
Agricultural	(mgd)	12.1	14.6	14.6
Total	(mgd)	933.3	1635.6	2910.0
Reqd.Surface Water Augmentation	(cfs)	1380.0*	2380.0*	4350.0*
Reqd. Fresh Water Augmentation	(cfs)	0.0	38.7	526.0

*Gross requirements to be satisfied by fresh and brackish water.

UPPER DELAWARE

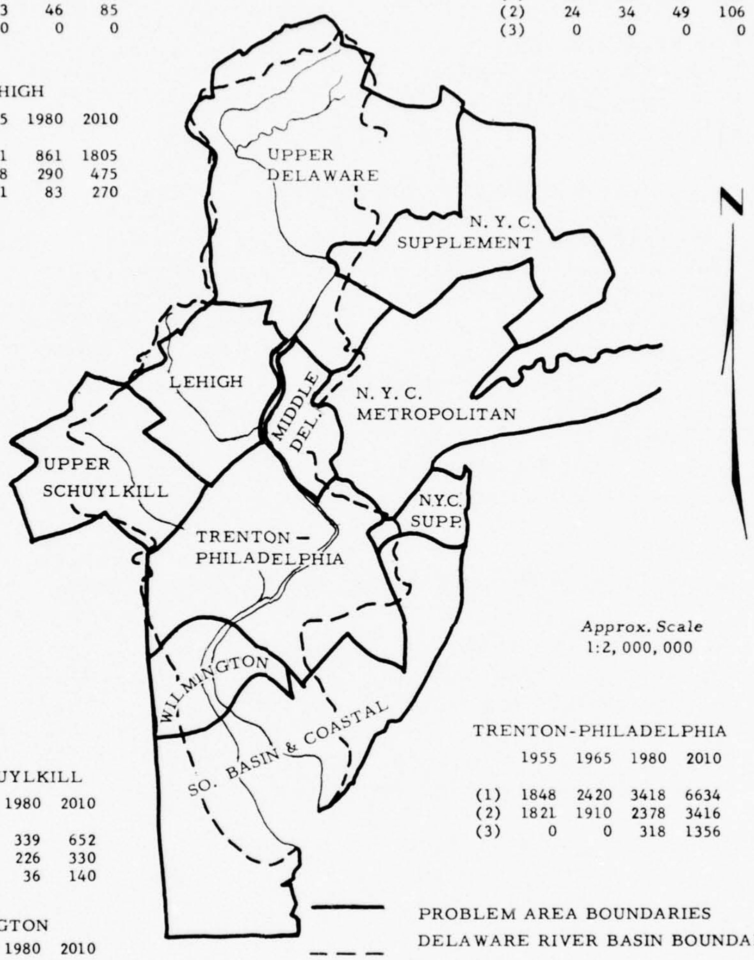
	1955	1965	1980	2010
(1)	40	54	74	128
(2)	21	33	46	85
(3)	0	0	0	0

MIDDLE DELAWARE

	1955	1965	1980	2010
(1)	43	58	80	156
(2)	24	34	49	106
(3)	0	0	0	0

LEHIGH

	1955	1965	1980	2010
(1)	430	591	861	1805
(2)	206	238	290	475
(3)	0	31	83	270



Approx. Scale
1:2, 000, 000

TRENTON-PHILADELPHIA

	1955	1965	1980	2010
(1)	1848	2420	3418	6634
(2)	1821	1910	2378	3416
(3)	0	0	318	1356

UPPER SCHUYLKILL

	1955	1965	1980	2010
(1)	168	238	339	652
(2)	121	176	226	330
(3)	0	0	36	140

PROBLEM AREA BOUNDARIES

DELAWARE RIVER BASIN BOUNDARY

WILMINGTON

	1955	1965	1980	2010
(1)	271	1085	1771	3113
(2)	240	993	1636	2910
(3)	0	0	25	340

LEGEND:

(1) GROSS WATER NEEDS
(2) NET SURFACE NEEDS
(3) REQUIRED FLOW AUGMENTATION

SO. BASIN & COASTAL

	1955	1965	1980	2010
(1)	86	165	257	494
(2)	13	20	26	42
(3)	0	0	0	0

All quantities in million gallons per day.

GROSS AND NET WATER NEEDS IN PROBLEM AREAS OF THE DELAWARE RIVER BASIN

PLATE 7

for local protection projects on tributaries of the Lackawaxen River, in the Paulins Kill, Little Schuylkill River and Brandywine Creek Watersheds and in the Town Bank area in New Jersey. Major Federal projects for control of floods in the basin are the Jadwin and Prompton Reservoirs in the Lackawaxen River Basin, Bear Creek Reservoir in the Lehigh River Basin and local protection projects at Allentown and Bethlehem, Pennsylvania. Pertinent data on the three Federal reservoirs are given in table VI-3.

TABLE VI-3

DATA ON FEDERAL RESERVOIRS EXISTING OR UNDER CONSTRUCTION

Reservoir	Stream	Drainage Area Controlled in Square Miles	Flood Control Capacity in Acre-Feet
Prompton	Lackawaxen River	60	20,300
Edgar Jadwin	Dyberry Creek	65	24,500
Bear Creek	Lehigh River	288	108,000

102. The requests by local interests for relief from flooding were varied and numerous. Included were requests for channel clearing, dredging, dikes, floodwalls, small flood detention structures and other measures to alleviate flooding at flood-stricken areas in general and at specific localities in the basin. Among the latter were Milanville, Pennsylvania, and Godeffroy, Port Jervis and Tristate, New York in the Upper Region of the basin; Stroudsburg-East Stroudsburg, Northampton, Easton and Tamaqua, Pennsylvania in the Central Region; and Bristol, Langhorne Terrace, New Hope, Sellersville, Ft. Washington, Yardley, and Bucks County, Pennsylvania and East Riverton, New Jersey in the Lower Region of the basin.

103. Flood control needs of the basin were defined from assessment of all types of damages associated with rainfall and runoff. These include damages to land productivity at the uppermost headwater areas arising from splash erosion, surface compaction, and surface sealing from rainfall impact, and sheet and gully erosion from surface runoff. The Department of Agriculture in studying the needs in these areas found, as reported in appendix K, that these needs could best be expressed in the areal extent of various land capability classifications. Measures to satisfy these needs can be accomplished under continuing land management programs and, therefore, were not defined in detail in this investigation.

104. The extent of the flood problems arising from excessive flows in creeks and streams as they convey runoff to the sea were assessed in

terms of the average annual monetary value of the damages in the intermediate upstream areas and the principal watercourse areas. These problems were expressed in terms of average annual flood damages. The latter were then translated through planning procedures into demands on water resources in terms of the control needed to assure desirable limits of flooding at particular places and times. The effects of all existing flood control projects as well as projects under construction were taken into account in the assessment of needs for flood control.

105. Major floods in the Delaware River Basin are usually associated with severe storms resulting in widespread heavy precipitation, and often accompanying hurricanes. The disastrous flood of August 1955 was of the latter type. Total damages from this flood, as determined by a field survey, were estimated to be about $124,000,000 at 1958 price levels (see appendix D). Of this total $86,700,000, or 70 percent, were recurring type damages along the main stem and its principal tributaries. The remaining 30 percent were either non-recurring damages or damages in the uppermost headwater and intermediate upstream areas. Average annual flood damages along the main stem and its principal tributaries, under natural conditions in 1958, are estimated to be approximately $9,230,000 at January 1959 price levels. Existing flood control measures and projects under construction will eliminate $3,130,000 of these damages, leaving residual average annual flood damages of approximately $6,100,000. In addition, studies of flood damage on the intermediate upstream tributaries have shown that average annual damages in these reaches are approximately $1,770,000, as discussed in appendix R.

106. Continued development of the flood plain will increase the damage potential. Estimates have been made of prospective average annual damages reflecting projected trends of development in the flood plain. These projections, discussed in appendix D, indicate that average annual damages along Delaware River, Lehigh River, and Schuylkill River, and their respective tributaries, will increase from a total of approximately $5,950,000 in 1958 to $6,820,000 by 1980, and $8,040,000 by 2010. These figures, based on 1959 price levels, may be taken as an indication of the increases in damages that are in prospect throughout the basin if adequate flood protection is not provided. The present and projected magnitude of flood damages in these basins and also in the Lackawaxen River Basin are shown in table VI-4.

TABLE VI-4

PROSPECTIVE AVERAGE ANNUAL FLOOD DAMAGES 1/ BY REACHES OF PRINCIPAL WATERCOURSES FOR YEARS 1958, 1980 AND 2010

River Reach	1958	1980	2010
Delaware R. and tributaries	$3,420,000	$3,870,000	$4,520,000
Lehigh R. and tributaries	1,180,000	1,290,000	1,440,000
Schuylkill R. and tributaries	1,350,000	1,660,000	2,080,000
Lackawaxen R. 2/	144,000	144,000	144,000
BASIN TOTAL	6,094,000	6,964,000	8,184,000

1/ 1959 price level

2/ No significant flood plain development anticipated in Lackawaxen River Basin

107. OUTDOOR RECREATION OPPORTUNITES. In studies by the National Park Service and the Corps of Engineers, as reported in appendices I and W, it was shown that water resources and projects for their development provide important opportunites for outdoor types of recreation. Water dependent recreational activities such as swimming, fishing, and boating are very popular and facilities to satisfy demands have been developed throughout the area. Extensive facilities have been developed also for picnicking and overnight camping and while these activities are not necessarily water dependent they take on an added degree of attractiveness when provided in association with water. At the present time public and private lakes or reservoirs developed specifically for recreation, and provisions for recreation at natural park-type areas and at facilities designed for other purposes serve to satisfy a major part of the needs for outdoor recreation opportunities. Requests by local interests for the development of recreation opportunities were expressed only in general terms until the plan of development was in advanced stages of its formulation. As the elements of the plan were identified, interest was shown by State and local planners in the exploitation of the recreation potentials.

108. In 1955 the 21.6 million people residing in the water service area engaged in outdoor activities estimated at 137,700,000 visitor-days of one-day outings, 75,800,000 visitor-days of overnight or week-end outings, and 132,000,000 visitor-days of vacations away from home. The demands for facilities sustaining one-day outings are the most critical of all the recreation requirements of the Delaware River water service area. Studies reported in appendix W indicate that the recreation opportunities to be derived from the development of the water resources may satisfy a considerable part

of these demands. It was found also that water impounding developments and state parks offer opportunities for essentially the same recreation activities. Therefore, the present and projected needs satisfied by public programs of state park type facilities are the type that recreation at water resources developments can effectively satisfy.

109. In 1955 the state parks and other non-urban state park type facilities in or adjacent to the Delaware River water service area could accomodate about 17.9 million people annually. Studies of selected state parks indicate that the attendance in 1955 varied from 8 to 100 percent above their reasonable capacity. There was a need for facilities, in 1955, to accommodate 15.7 million visitors in addition to the existing capacities. Projections of the rate of growth of the recreation demand were made by considering the combined effects of an ever-increasing population that is essentially urban, and an expanding economy. Demands for state park type recreation opportunities are expected to increase to about 6.7 times the 1955 demand at year 2010 as indicated in table VI-5.

TABLE VI-5

PROJECTED STATE PARK TYPE RECREATION NEEDS FOR DELAWARE RIVER WATER SERVICE AREA

Year	State Park Attendance
1955	33,600,000
1965	55,800,000
1980	98,700,000
2010	227,000,000

110. The broad treatment of recreation needs of the entire Delaware River Basin and related study areas contained in appendix I points out that the geographic needs of the basin are primarily concerned with recreation space, recreation facilities and accessibility. In addition to the basic recommendation of the need for recreation development of areas surrounding proposed water control projects, it includes a plan for the preservation and utilization of outstanding natural, scenic and historical features as well as the development of areas for intensive recreation use, such as beach areas on the lower Delaware River and the New Jersey and Delaware shores. The recreation potentials at water resources projects under consideration would, if fully developed, meet a considerable portion of the non-urban recreation needs of the Delaware River Basin.

111. ELECTRIC POWER. The electric power requirement of the area which would be affected by any plan of development for the Delaware River and its tributaries exceeded 55 billion kilowatt-hours in 1957, with a peak demand of 11.1 million kilowatts. The hydropower developments in and adjacent to the service area in 1957 accounted for approximately seven percent of the total installed (rated) capacity of generating facilities in the pertinent power marketing area as defined in appendix F. The capacities in the basin were located as follows. 40,000 kilowatts at a plant on Wallenpaupack Creek, 26,000 kilowatts at four plants on Mongaup River, and, 1900 kilowatts at several small manufacturing companies. Water diverted from the basin to supplement New York City's water supply is used to generate hydroelectric power at 25,000-kilowatt and 18,000-kilowatt plants located just outside the basin boundaries. Four hydroelectric plants on the Susquehanna River having a total installed capacity of 613,000 kilowatts also supply hydroelectric energy to the utility systems serving the Delaware River Basin.

112. At the public hearings in 1956, local interests requested that the hydropower potentials at the Tocks Island, Belvidere and Chestnut Hill dam sites on Delaware River be developed. Both public and private developments for these power potentials were requested. At the public hearing at Phillipsburg, New Jersey on 13 April 1960, the New Jersey Power and Light Company expressed a willingness to purchase and market, at its expense, any power generated at conventional hydropower facilities at the Tocks Island Project, and to construct and/or operate these facilities at its expense. The Company also proposed to build and operate, at its expense, a pumped-storage power project in conjunction with the Tocks Island development.

113. Estimates of future power requirements were based on a detailed analysis of the growth of each of the principal classes of electric utility service, and on an extension of the indicated trends and rates of growth of the total requirements to the year 2010. Details of these estimates are presented in appendix F and a summary is given in table VI-6.

TABLE VI-6

PAST AND ESTIMATED FUTURE UTILITY POWER REQUIREMENTS
IN DELAWARE RIVER SERVICE AREA
1950 - 2010

Year	Energy for Load (Millions of kwh.)	Peak Demand (Thousands of kw.)	Load Factor (Percent)
1950	35,028	7,403	54.1
1955	49,027	10,145	55.2
1957	55,142	11,106	56.7
1960	66,600	13,440	56.4
1965	88,100	17,490	57.5
1970	113,900	22,230	58.5
1975	144,500	27,720	59.5
1980	180,400	34,000	60.4
1985	222,100	41,500	61.3
1990	270,300	49,600	62.2
1995	325,700	59,000	63.0
2000	389,000	69,500	63.7
2005	461,200	82,000	64.3
2010	543,500	96,000	64.8

114. For a further indication of future power needs in the general region of the service area, the future needs of two interconnected utility systems, which serve a major portion of the service area, were examined. The installation of over 16.5 million kilowatts of capacity by 1980 will be required to take care of the expected load in that year in the area served by the utilities in the Pennsylvania-New Jersey-Maryland interconnection, which is defined in appendix F. The interconnected system of the New York State Electric and Gas Company, to meet its future load, will be required to install nearly 1.1 million kilowatts of new generating capacity between 1960 and 1980. The Federal Power Commission has indicated in appendix F that for proposed hydroelectric developments at water resources projects under consideration, there will exist a ready market for all energy that can be economically produced at these sites. The Department of the Interior, as the prospective marketing agency for the Federally-produced energy that might be generated at proposed projects, reviewed and generally concurred in the views of the Federal Power Commission regarding the marketability of such energy. The full statement of the Department of the Interior is contained in exhibit A of appendix T.

115. NAVIGATION. Delaware River and its tributaries were once important highways of commerce over the entire length of the basin from the headwaters to the capes. However, navigation above Trenton, by rafts, barges, and other shallow-draft vessels, declined with the advent of competing transportation facilities. There is at present little indication of either need or desire for navigation improvements in the basin above Trenton, and there appears to be little prospect at this time that a demand will develop. Navigation was included as one of the purposes to be served by a multiple-purpose plan of development for the basin's water resources as requested by local interests at hearings. Later inquiries made during the study failed to disclose any interest in the provision of navigable channels above Trenton.

116. Delaware River from Trenton to the sea is a busy and important navigable waterway. Authorized Federal navigation projects provide for a channel 40-feet deep from the sea for 126.3 miles to Newbold Island, thence 35-feet deep for about 5-1/2 miles to Trenton Marine Terminal, thence 12-feet deep for about 1-1/4 miles to the Pennsylvania Railroad Bridge in Trenton. Appurtenant facilities and numerous tributary channels on both sides of Delaware River and Bay are also provided under the existing projects. The economic growth of the region has been directly related to the provision and maintenance of adequate navigation facilities, and the development of these facilities has generally kept pace with demand. Modification of existing projects to accommodate the increasing size and numbers of vessels calling at Delaware River ports is accomplished as the need therefor develops.

117. A study of navigation requirements and facilities, presented in appendix E, has indicated that the current and foreseeable interests of navigation are being adequately served by existing projects and proposed modifications, and that future demands will be satisfied by established procedures. It was found that navigation in Delaware River does not have a present or foreseeable need for low flow augmentation, and would not receive significant benefits from regulated flows.

118. FISHERIES. The waters of the Delaware River Basin support a wide variety of both cold and warm fresh-water fishes, marine fin-fish and shellfish in Delaware Bay and vicinity, and anadromous and catadromous species which make use of both the tidal waters and the fresh water streams. The fish and wildlife resources of the basin are discussed in appendix J. The fresh-water fishes include the cold water species, trout, which are most populous in the streams and to a lesser extent in the lakes and ponds of the Upper Region; and the warm water species, such as bass, pickerel, walleye, and various pan fishes, which occur principally in the lakes, reservoirs, and some of the larger streams in the Upper Region. Heavy demands by anglers, shortage of available fishing areas, lack of public access to available areas, and

the reduction of habitat quality as a result of contamination by sediment and industrial and/or municipal wastes have created serious fresh-water fisheries problems.

119. The requested general improvements in the interest of fisheries included "fishways" at projects located on the principal water courses and cooperative planning to avoid possible adverse effects of water resource developments on fish and wildlife. General requests for a multiple-purpose plan of development for the water resources of the basin included fish and wildlife as a project purpose, and this was considered as including the development of the fish and wildlife potentials at water impounding projects under consideration and at stream reaches below such projects.

120. The commercial and recreational marine fisheries of Delaware Bay are among the most productive of the North American continent. Commercial operations resulted in combined landings for New Jersey and Delaware of 890 million pounds in 1956. Fifty species of fin-fish and twelve species of shell-fish are included in the commercial catch. The total commercial value of the catch is about $13,000,000 annually, with menhaden and oysters comprising over half the total. In 1955 the landings in the Delaware Bay area included approximately 22 percent of the menhaden and 27 percent of the clams caught in the continental United States, including Alaska, and 13 percent of the eastern oysters. During the same year, when the United States ranked second among nations of the world in total catch of commercial fisheries, Lewes, Delaware, ranked third amoung the nation's ports in landings, with more than 308 million pounds of fish, mostly menhaden. The recreational value of the marine fishery is attested by the approximately 130,000 salt-water sport fishermen who devote about 900,000 man-days to fishing in the Delaware Bay area each year.

121. Principal problems associated with the marine fisheries include: detrimental effects of storms, sedimentation, dredging and filling operations, industrial and municipal expansion, agricultural expansion, use of pesticides, and various types of pollution. Need exists for data on ecological conditions, and on the effects of current and potential human demands. Adequate facilities are needed to permit optimum recreational use of available resources. Important anadromous fishes of the basin are shad, herring and striped bass. The only catadromous species is the eel. Runs into Delaware River and its tributaries by all these fishes have displayed a downward trend during the past several decades, principally due to pollution in Delaware River between Torresdale and Marcus Hook. Within the past two or three years, however, runs of shad, herring and striped bass have increased in size. It is considered that the future demands placed on water resources by fisheries will be principally related to water quality.

Any marked change in the nature of the available water may adversely affect the fisheries, and any contemplated major physical change should be carefully considered in the light of its effect on the water and dependent fishery.

122. WILDLIFE. In studies reported on in appendix J it was found that the Upland Region of the basin is particularly important as habitat and hunting area for white-tailed deer and smaller forms of forest game. Large numbers of pheasants, cottontail rabbits, and deer are supported in much of the Central Region, and these resources attract an extremely heavy sportsman use. The Coastal Plains provide a limited amount of high quality upland game land, but they support a significant amount of recreational use. The broad marshes of the Lower Region section are of particular wildlife value, providing a habitat area for millions of migratory birds, including ducks, geese, rails, and a wide variety of other marsh and shore bird species. They also provide habitat for muskrats, which have important economic values for many local residents.

123. Wildlife population in the basin and its relationship to the future economy and recreation of the area, provide a basis for determining related water resource demands. Continued expansion of the economy and population will place an ever-increasing pressure on these wildlife populations. Development of the water resources should be accomplished with full consideration of the needs for hunting.

124. WATER QUALITY. The Public Health Service in its study of water quality, as reported in appendix C, relied upon dissolved oxygen content of the water as an indication of stream quality conditions. Dissolved oxygen is of primary interest only when it falls below certain limits, thereby inhibiting particular water uses. For example, various standards have been adopted fixing desirable limits at not less than 4.0 or 5.0 parts per million (ppm) of dissolved oxygen. Some regulating agencies feel that these limits are necessary to maintain both a varied fish population and "healthy" flora and fauna in the streams. A stream or body of water is considered septic when the dissolved oxygen approaches depletion. The upper limit (or saturation) for dissolved oxygen depends on water temperature and many other factors, but for comparative purposes it may be assumed to be of the order of magnitude of 10 ppm.

125. The headwaters of the Delaware River Basin in the area from Port Jervis, New York to Easton, Pennsylvania, are generally of excellent quality in all respects. Increased population densities and industrialization in the vicinity of Easton and in the Lehigh River valley result in a slight degradation in the quality of the Delaware River below the confluence of the Lehigh River. From Easton to Trenton, New Jersey, the stream characteristics indicate that the water is presently of good quality and capable of serving a variety of uses. The dissolved oxygen

profiles of the Delaware River above Trenton, as defined in appendix C, are shown in figure 1, plate 8. Considering the projected increase in population for 1965 and 1980, it is expected that there will be no change in the dissolved oxygen content of the river from the headwaters to Trenton because expanded sewering and sewage treatment will take care of the increased pollution load as the population rises. In general, the Delaware River in this reach can be expected to be of such quality as to support a wide variety of water uses during the period ending at year 2010.

126. The dissolved oxygen profiles for the tidal section of the Delaware River from Trenton to Delaware Bay are shown in figure 2, plate 8. Studies by the Public Health Service indicate that in this reach of the river a decrease in pollution loading took place from 1950 to 1957; however, the dissolved oxygen levels were not materially affected. Based on correlations of pollution load, annual temperatures and 90-day average flows at Trenton with annual dissolved oxygen, the Public Health Service concluded that changes in annual dissolved oxygen levels were determined to a large degree by variations in the amounts of fresh-water inflow across any one year. From this it was concluded further that variations of dissolved oxygen within any one year reflect variations in fresh water flows. Increased population and industrial activities for the period to 2010 will result in an increase in the present total pollution load to Delaware River below Trenton as shown in table VI-7.

TABLE VI-7

ESTIMATED POLLUTION LOAD AND TRENDS IN DISSOLVED OXYGEN

YEAR	TOTAL POLLUTION LOAD 1/	ANNUAL AVERAGE DISSOLVED OXYGEN IN % OF SATURATION AT BEN FRANKLIN BRIDGE	AT MARCUS HOOK
1940	1,000,000	31	40
1950	880,000	37	40
1957	780,000	31	33
1958	770,000	4/	4/
1980	930,000 2/	5/	5/
2010	900,000 3/	5/	5/

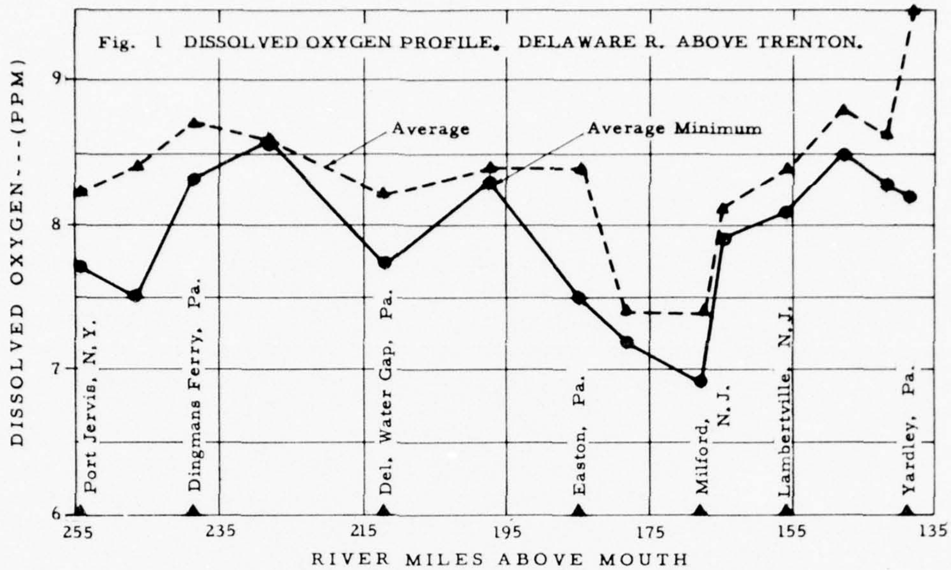
1/ 5-day average biochemical oxygen demand (BOD), pounds per day.

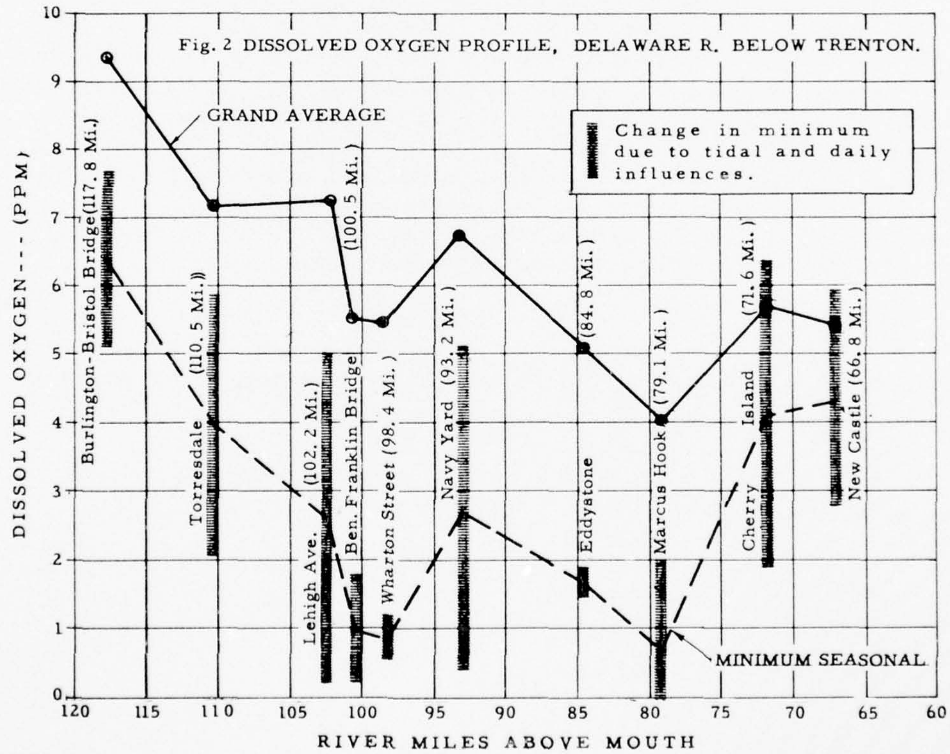
2/ Based on median conditions of removal efficiency (50%) of total load from tributary areas.

3/ Based on best conditions of removal efficiency (70%) of total load from tributary areas. 1,400,000 lbs. BOD per day based on present conditions of removal efficiency (30%) of total load.

4/ Not available.

5/ Not projected because of the dominant influence of prevailing stream flows, which will vary.





DISSOLVED OXYGEN PROFILES

PLATE 8

127. Based on trends in historical water qualities for various pollution loads for the years 1940, 1950 and 1957 as shown in table VI-7, it is estimated that water quality at year 2010 will be between the conditions which existed in 1940 and those which existed in 1950. However, increasing industrial technologies in the future may result in complex organic chemical constituents assuming greater importance than BOD in the assessment of future stream quality conditions. Should substantial pollution removal not be accomplished, the quality of the estuary will progressively deteriorate. However, the efforts of the various water pollution control agencies which have been so effective in the past can be assumed to continue, and it does not appear that quality conditions will be allowed to retrogress to the levels of 20 years ago.

128. WATER DEMANDS ARISING FROM LAND USE. A primary demand placed on available supplies of water arises from use of the land areas. The extent of present demands of this nature are reflected in the available ground and surface waters of the basin. However, future changes in land use could materially alter present water supply conditions. As a basis for assessing the probable extent of such changes the Department of Agriculture defined anticipated land use patterns at selected years in the future and reported on these in appendix K. The extent and nature of present and anticipated major uses of land in the basin are as shown in table VI-8.

TABLE VI-8

PRESENT AND FUTURE MAJOR LAND USES IN DELAWARE RIVER BASIN 1/

Major	Area 2/ in Use at Years Shown			
Uses	Current	1975	2010	2060
Cropland	2.3	2.1	1.9	1.7
Pasture	0.4	0.4	0.3	0.3
Woodland	3.7	3.3	3.1	2.9
Idle	0.3	0.3	0.3	0.3
Urban	0.7	1.3	1.8	2.2

1/ Excludes 0.8 million acres in various other uses.
2/ Millions of acres in rounded figures.

129. General evaluations of the probable effects of these anticipated changes in land use indicate that water losses through

consumptive plant transpiration should decrease modestly as additional lands are converted to urbanization over the 50-year-development period under consideration. Decreases in these losses would tend to increase, by very small amounts, the available ground and surface waters. The expanding urbanization also would tend to increase the magnitude and increase the frequency of local flooding in the areas affected by this expansion.

130. SEDIMENTATION. Sheet erosion is believed to be the predominant source of sediment in the lower part of the basin; channel erosion and bank scour are considered to be the principal sediment sources in the steep upland areas. It was found in studies reported on in appendix H that the sediment loads vary, both in time and place and that most of the sediment in the Delaware River Basin is transported by a relatively few intense storms. Annual suspended-sediment loads of the Delaware River at Trenton, based on eight years of record, range from 59 to 342 tons per square mile, equivalent to depths ranging from 0.0005 to 0.003 inches, respectively, from each unit of the surface area. The estimated average annual load of tributaries varies from 33 tons per square mile on the Bushkill to 270 tons per square mile on Neshaminy Creek. Suspended sediment concentrations in streams in the basin are low much of the time. The combined average annual suspended load during the period 1954-1957 for the Delaware River at Trenton, New Jersey, the Schuylkill River at Philadelphia, Pennsylvania and Brandywine Creek at Wilmington, Delaware, was 1.41 million tons or 158 tons per square mile of drainage area. If the same load applies to the remainder of the basin, a total of approximately two million tons are lost from the basin annually. If the same conditions of cover and land use were continued for 50-years, the indicated loss would be 100 million tons, equivalent to a depth of about 0.067 inches from the entire land surface of the basin. While this indicated loss may be pessimistic there is little doubt that definite needs exist for land treatment, bank protection and other measures to preserve the surface soils of the basin and diminish the sediment inflow to channels and harbor developments in the tidal section of the river.

131. DRAINAGE. Water resource development must include consideration of the drainage or other management of coastal marsh areas, interior swamp areas, and other wetlands, as appropriate. Primary interest in these areas in the Delaware Basin has been centered on their relationship to fish, wildlife and recreation. Efforts have been made to drain certain critical areas in the interest of mosquito control. Drainage was provided for salt hay culture and other agricultural purposes. Diking of extensive tidal marsh areas in Delaware and New Jersey and the provision of sluices to control water levels in the areas were conducive to the production of muskrats, which was of noteworthy significance. Local interests requested that

measures be provided to improve drainage impeded by the disposal of material dredged from the navigation channel and anchorages. The State of Delaware, in appendix O, attaches great significance to the marshlands as potential food and material production sites. In this respect, experiences with low-level land reclamation in Holland are cited as indicative of what could be accomplished in some areas of the Delaware basin by the construction of dikes, and a drainage control system to gradually wash salinity from the diked areas.

132. <u>SUMMARY</u>. Local interests favor, generally, the development and execution of a comprehensive multiple-purpose plan for the development of the water resources of the Delaware River Basin. However, specific requests at hearings and by correspondence related, primarily, to flood control and the relief from flood damages. The desires of local interests with regard to the goods and services to be gained by a comprehensive plan of improvements were developed generally through working arrangements between Federal agencies cooperating in the investigation and their State and local counterparts.

133. In assessing the dimensions of the overall markets for the products of water resources development it was found that, in addition to the requirements for the control of flood flows, projected populations and industrial activities indicated a very significant need for the conservation and control of surface flows of all magnitudes to assure adequate supplies of water in the future to sustain municipal, industrial and rural activities. Also, projections of population, personal income and leisure time indicated a compelling need for state park type facilities for recreation. The projected population and industrial activities over the 50-year period under consideration indicated, further, an ever-expanding demand for electric energy. This demand assures a ready market for electrical energy that can be economically produced at water resource projects. Thus, major needs for the products and services to be gained from development of the basin's water resources were found to be in the fields of flood control, water supply, recreation and hydroelectric power.

134. Demands for other products and services such as navigation, fish and wildlife preservation, water quality, land use, sedimentation, and drainage, usually associated in varying degrees with water resources, were found to create no direct requirements for developments which could be included in the scope of the proposed plan. This is not to say that they place no requirements on water resources but, rather, that they are or can be satisfied under present conditions of development or as incidental requirements placed on future developments.

135. The needs for the products of water resources development determines the nature and scope of a comprehensive plan to satisfy the demands. Some of these needs are competitive. Irrigation is a consumptive use of water and competes with other uses for its share. Water supply, power and recreation require semi-permanent pools of water stored on a long-term basis in reservoirs while the temporary or short-term storage of excess flood flows requires that an empty reservoir or additional capacity above semi-permanent pools be provided. Urban expansion frequently takes over agricultural land and often increases the threat of flooding. To satisfy, in a balanced manner, the needs engendered by these factors, it is necessary to provide improvements to control and utilize the water resources of the Delaware River Basin.

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CHAPTER VII

PLAN FOR DEVELOPMENT OF WATER RESOURCES

136. DEFINITION OF THE PLAN. In formulating the plan to satisfy the needs of the basin for the products and services of water resource development, a variety of measures were considered. These measures fall into three distinct categories: (a) major control impoundments to regulate streamflow in the principal watercourses and to provide pools for recreation, fish and wildlife habitat and the production of hydroelectric power; (b) small control impoundments to regulate streamflow in local upstream reaches and to provide pools to satisfy local recreation needs; and (c) measures and programs for land and water use to eliminate or ameliorate needs by environmental changes. These three types of measures are not entirely independent since they act together in complimentary fashion to contribute to the overall effectiveness of the plan either by direct satisfaction of needs through measures to control extreme flows and/or by indirect satisfaction of needs by removal of contributory causes.

137. The first category of measures considered is represented in the plan by a proposed system of major dams and reservoirs, the second by a proposed system of small dams and reservoirs, and the third category by a variety of related programs. Included in the latter are land management, soil conservation, reforestation, control of use and occupance of the flood plain, conservation of water by reuse in industry, improvement of water quality by removal of pollution loads, and continuation and improvement of hydrologic data collection with particular reference to water use, groundwater quantities and characteristics, and water quality.

138. The broad principles followed in the formulation of the plan of development were: (a) that the needs for products and services of water resource development are real in the sense that they exist or will come into existence at indicated dates during the next 50 years; (b) that the plan provide for congruent satisfaction of expanding needs in a balanced manner with the least investment in water resources and funds; and (c) that the scale of development of each project be such as to provide the maximum excess of benefits over costs. The first of these principles provided the planning criteria for selection of an array of projects having capabilities for meeting the needs in a timely manner. The second principle imposed the planning requirement of selecting the most economical projects from a variety of alternatives and times for their development. The third principle required the definition of project sizes and internal allocations to various project purposes in such manner as to define, where practicable, the optimum

level of development as indicated by the greatest justifiable excess of benefits over costs. The selection and sizing of the projects and programs included in the three categories of measures referred to above constituted the formal planning studies made in connection with this investigation and reported in detail in the appendices.

139. MAJOR CONTROL PROJECTS. Projects to satisfy major segments of widespread needs for supplies of raw water, flood control in the principal watercourse areas, recreation, hydropower and other products of water resources development were selected from successive determinations by discrete screenings applied to 193 potential major dam sites in all parts of the basin. Further evaluations were applied to seven of these to assure maximized net returns from the major control projects. Nineteen major control projects were selected as elements of the plan of development. These projects are scheduled for varying degrees of initial development. The first group of eleven projects, listed in geographic order from upstream to downstream in table VII-1, would be developed for multiple-purposes at indicated times prior to year 2010. The second group of eight projects, also listed in the same geographic order in table VII-1, would be initially developed prior to year 2010 for the sole purpose of recreation with multiple-purpose development deferred to the time of need some time after year 2010. The major control projects in the plan are described individually in paragraphs 165 to 185 below and their locations are indicated on plate 9 bound at the end of the text.

140. *General characteristics of the major control projects*. The basic functions of the proposed major impoundments are characteristically associated with storage allocations that are used either for short-term impoundments, as for the control of excess flood flows, or for long-term impoundments, as in the case of seasonal and annual carryovers for water supply, recreation and power generation. Of the 19 major control projects, eight will have short-term storage allocations for the control of flood flows, eleven will have long term storage allocations for augmenting supplies of raw water, two will have long term storage allocations and facilities for the generation of hydroelectric power, and all of the 19 projects will have facilities to exploit the recreation potentials of the general project areas. The recreation lands and facilities to be provided at the eleven major projects proposed for multiple-purpose development prior to year 2010 have been placed in two general categories; (a) those that would be directly related to development of water resources at the site; and (b) those that would be indirectly associated with the water resource development. The directly related facilities include beaches, boat ramps, picnic areas, overnight camp grounds, roads, parking areas and other improvements for recreation in the vicinity of the proposed water area. The indirectly related facilities include group camping grounds, overlooks, recreational administration areas and other recreation facilities in the peripheral areas at a distance from the water.

TABLE VII-1

WATER CONTROL PROJECTS IN PLAN OF DEVELOPMENT

Project	Stream	Drainage Area Gross (sq.mi.)	Drainage Area Net (sq.mi.)	Long-Term Inactive Capacity (ac. ft.)	Long-Term Inactive Elevation Top of Pool (ft.m.s.l.)	Long-Term Active Capacity (ac. ft.)	Long-Term Active Elevation Top of Pool (ft.m.s.l.)	Short-Term Capacity (ac. ft.)	Short-Term Elevation Top of Pool (ft.m.s.l.)	Total Capacity (ac. ft.)	Total Elevation Top of Pool (ft.m.s.l.)	Indicat[ed] Complet[ion] Date
				STORAGE AND POOL ELEVATIONS								
MAJOR CONTROL PROJECTS												
Hawk Mountain	E.Br.Delaware R.,N.Y.	812	440 1/	60,000	1,008	233,000	1,082	-	-	293,000	1,082	2001
Prompton 2/	Lackawaxen R., Pa.	60	60	3,400	1,125	28,000	1,180	20,300	1,205	51,700	1,205	1974
Tocks Island	Delaware R.,N.J., Pa.	3,827	2,412 3/	80,000	356	410,000	410	275,000	428	765,000	428	1975
Bear Creek 2/	Lehigh R., Pa.	288	288	2,000	1,300	70,000	1,425	108,000	1,481	180,000	1,481	1989
Beltzville	Pohopoco Cr., Pa.	97	75 4/	1,200	525	40,000	615	27,000	641	68,200	641	1965
Aquashicola	Aquashicola Cr.,Pa.	66	66	1,000	435	24,000	483	20,000	503	45,000	503	1981
Trexler	Jordan Cr., Pa.	51	51	800	416	24,200	479	14,000	492	39,000	492	1972
Maiden Cr.	Maiden Cr., Pa.	161	161	2,000	323	74,000	381	38,000	394	114,000	394	1982
Blue Marsh	Tulpehocken Cr., Pa.	174.5	174.5	1,500	249	14,500	279	33,000	303	49,000	303	1969
Newark	White Clay Cr., Del.	67	67	1,000	98	30,000	156	-	-	31,000	156	1975
Christiana	Christina R., Del.	41	41	1,000	23	36,000	49	-	-	37,000	49	1980

1/ Below Pepacton Reservoir
2/ Modification of existing authorized flood control project
3/ Below Cannonsville, Pepacton, Hawk Mountain, Neversink and Prompton Reservoirs
4/ Below Wild Creek Reservoir

MAJOR CONTROL PROJECTS TO BE DEVELOPED IN TWO STAGES
(STORAGE AND POOL ELEVATIONS FOR 2ND STAGE MULTIPLE-PURPOSE POOL)

Project	Stream	Drainage Area Gross (sq.mi.)	Drainage Area Net (sq.mi.)	Long-Term Inactive Capacity (ac. ft.)	Long-Term Inactive Elevation Top of Pool (ft.m.s.l.)	Long-Term Active Capacity (ac. ft.)	Long-Term Active Elevation Top of Pool (ft.m.s.l.)	Short-Term Capacity (ac. ft.)	Short-Term Elevation Top of Pool (ft.m.s.l.)	Total Capacity (ac. ft.)	Total Elevation Top of Pool (ft.m.s.l.)	Indicat[ed] Complet[ion] Date
Paulina	Paulins Kill, N.J.	122	122	4,000	403	51,000	465	-	-	55,000	465	6/
Pequest	Pequest R., N.J.	100	100	3,000	455	38,000	507	-	-	41,000	507	6/
Hackettstown	Musconetcong R., N.J.	70	70	1,000	630	22,000	665	-	-	23,000	665	6/
New Hampton	Musconetcong R., N.J.	123	53 5/	2,000	375	42,000	426	-	-	44,000	426	6/
Tohickon	Tohickon Cr., Pa.	75	75	1,500	335	30,000	388	-	-	31,500	388	6/
Newtown	Neshaminy Cr., Pa.	150	150	2,000	114	60,000	176	-	-	62,000	176	6/
French Creek	French Cr., Pa.	47	47	1,300	240	25,700	289	-	-	27,000	289	6/
Evansburg	Skippack Cr., Pa.	54	54	1,500	125	23,500	166	-	-	25,000	166	6/

5/ Net area applicable upon completion of proposed Hackettstown Reservoir
6/ Early development for recreation is indicated with multi-purpose development after 2010

SMALL CONTROL PROJECTS

Project	Stream	Drainage Area Gross (sq.mi.)	Drainage Area Net (sq.mi.)	Long-Term Inactive Capacity (ac. ft.)	Long-Term Inactive Elevation Top of Pool (ft.m.s.l.)	Long-Term Active Capacity (ac. ft.)	Long-Term Active Elevation Top of Pool (ft.m.s.l.)	Short-Term Capacity (ac. ft.)	Short-Term Elevation Top of Pool (ft.m.s.l.)	Total Capacity (ac. ft.)	Total Elevation Top of Pool (ft.m.s.l.)	Indicat[ed] Complet[ion] Date
Parkside (Pc8)	Cranberry Cr., Pa.	6.8	6.8	52	768	-	-	2,218	822	2,270	822	7/
Swiftwater (Pc9)	Swiftwater Cr., Pa.	9.7	9.7	71	888	-	-	3,279	942	3,350	942	7/
Jim Thorpe (Hz6)	Mauch Chunk, Cr., Pa.	6.8	6.8	80	952	-	-	1,520	976	1,600	976	7/
Wa-16	West Brook, N.Y.	21.5	21.5	140	-	-	-	4,587	-	4,727	-	7/
On-2	East Brook, N.Y.	3.9	3.9	35	-	-	-	832	-	867	-	7/
Lm-2	N.Br. Callicoon Cr., N.Y.	13.8	13.8	96	-	-	-	2,944	-	3,040	-	7/
Pc-1	Devils Hole Cr., Pa.	4.8	4.8	40	-	-	-	1,022	-	1,062	-	7/
Pc-2	Rattlesnake Cr., Pa.	2.6	2.6	26	-	-	-	554	-	580	-	7/
Pc-5	Trib. Buck Hill Cr., Pa.	1.5	1.5	20	-	-	-	320	-	340	-	7/
Pc-6	Trib. Paradise Cr., Pa.	1.0	1.0	14	-	-	-	213	-	227	-	7/
Pc-7	Trib. Rattlesnake Cr., Pa.	1.5	1.5	20	-	-	-	320	-	340	-	7/
Pc-10	Forest Hill Run, Pa.	3.3	3.3	31	-	-	-	703	-	734	-	7/
Pc-11	Tank Cr., Pa.	2.2	2.2	23	-	-	-	469	-	492	-	7/
Bu-1	Leavitt Br., Pa.	5.3	5.3	43	-	-	-	1,129	-	1,172	-	7/
Bu-5	Poplar Run, Pa.	2.4	2.4	24	-	-	-	511	-	535	-	7/
Bu-6	Pine Mountain Run, Pa.	2.7	2.7	27	-	-	-	575	-	602	-	7/
Bu-7	Trib. Brodhead Cr., Pa.	1.2	1.2	15	-	-	-	256	-	271	-	7/
Bu-10	Trib. Brodhead Cr., Pa.	2.5	2.5	25	-	-	-	532	-	557	-	7/
Pc-12	Scot Run, Pa.	1.7	1.7	19	-	-	-	362	-	381	-	7/
Pc-13	Trib. Scot Run, Pa.	1.4	1.4	17	-	-	-	298	-	315	-	7/
Pc-14	Pocono Cr., Pa.	5.6	5.6	45	-	-	-	1,193	-	1,238	-	7/
Pc-15	Swamp Run, Pa.	2.5	2.5	25	-	-	-	532	-	557	-	7/
Pc-16	Trib. Pocono Cr., Pa.	1.2	1.2	15	-	-	-	256	-	271	-	7/
Pc-17	Trib. Pocono Cr., Pa.	1.2	1.2	15	-	-	-	256	-	271	-	7/
Pc-18	Reeders Run, Pa.	3.5	3.5	32	-	-	-	746	-	778	-	7/
Pc-19	Rocky Run, Pa.	2.4	2.4	24	-	-	-	511	-	535	-	7/
Pc-20	Bulgers Run, Pa.	1.7	1.7	19	-	-	-	362	-	381	-	7/
Pc-21	Cranberry Cr., Pa.	2.1	2.1	22	-	-	-	447	-	469	-	7/
Pc-22	Wigwam Cr., Pa.	1.7	1.7	19	-	-	-	362	-	381	-	7/
WG-1	E.Br. Monocacy Cr., Pa.	2.0	2.0	34	-	-	-	427	-	461	-	7/
DG-1	Little Martins Cr., Pa.	2.4	2.4	39	-	-	-	512	-	551	-	7/
WG-5	Bushkill Cr., Pa.	24.8	24.8	248	-	-	-	5,291	-	5,540	-	7/
Gt-7	Trib. Tacony Cr., Pa.	1.9	1.9	52	-	-	-	404	-	456	-	7/
Gt-10	Little Neshaminy Cr., Pa.	12.0	12.0	210	-	-	-	2,560	-	2,770	-	7/
Gt-11	Park Cr., Pa.	10.9	10.9	195	-	-	-	2,325	-	2,520	-	7/
Nt-1	W.Br. Stony Cr., Pa.	2.1	2.1	56	-	-	-	448	-	504	-	7/
Nt-2	Trib. Stony Cr., Pa.	2.4	2.4	61	-	-	-	512	-	573	-	7/
Gt-4	Trib. Sandy Run, Pa.	1.9	1.9	52	-	-	-	405	-	457	-	7/
Gt-13	Trib. Sandy Run, Pa.	1.0	1.0	37	-	-	-	213	-	250	-	7/

7/ Scheduling subject to programming under continuing authorizations and the desires of local interests.

These indirectly related facilities are not necessarily dependent on the water resource development but are essential to a fuller realization of the project's recreation potential. To provide sound planning bases, the recreation lands and facilities were designed as an integrated unit for development of directly and indirectly related recreation potentials for the major control projects. The overall recreation lands and facilities, thus defined for the various projects, were segregated, by field appraisals, office studies and professional judgment, into balanced developments for the directly related and indirectly related categories. The directly related recreation developments were used as bases for allocating project costs to recreation as a project purpose as described in the following chapter. From consideration of the general manner in which the indirectly related recreation lands and facilities would be associated with the overall project development, these indirectly related features were considered to be desirable recreation reserves for individual local development as local recreation needs and programming indicate to be desirable and warranted. Accordingly, the development of the latter features was not considered as a project purpose in cost allocations.

141. As indicated in table VII-1, eight projects in the first group will have a total of 535,300 acre-feet of short-term storage and all eleven projects in this group will have a total of 1,137,000 acre-feet of long-term storage. Of the latter, 153,900 acre-feet are provided as inactive storage to assure acceptable minimum pool surfaces for recreation, to compensate for the anticipated accumulation of sediment in the various projects during their useful life and, in the case of the Hawk Mountain and Tocks Island Projects, to assure desirable minimum operating levels for power generation. The overall effects of the first eleven major control impoundments on the stream flows in the basin and the extent and nature of the services to be gained from the plan of development are discussed in the following chapter of this report. The second group of eight major control projects when fully developed will have only long-term storage amounting to a total of 308,500 acre-feet, of which 16,300 acre-feet will be inactive. The specific functions of each major control element of the plan are discussed as features of the individual project description in subsequent paragraphs.

142. SMALL CONTROL PROJECTS. Projects for the control of the uneven stream flows at local problem reaches in the intermediate upstream areas were selected from successive evaluations of 386 potential small dam sites in the basin. The sites investigated in this category included all practical small dam and reservoir potentials to control drainage areas of one to twenty square miles in extent. Details of the study of small control projects are presented in appendix R. Thirty-nine small control projects, as listed in table VII-1, were found to have sufficient economic merit to warrant their inclusion in the plan of development. These

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projects are proposed for early development for local flood control; and for recreation, water supply and other purposes to the extent warranted by local needs as indicated by local interests at the time preconstruction studies are undertaken. Thirty-six of these proposed small control projects might be accomplished under existing programs and continuing authorizations contained in Public Laws 566 and 685; provided the detailed studies, required under these authorities, confirm the appraisals made herein. Three of the small control projects, namely, the Parkside, Swiftwater and Jim Thorpe Projects, exceed cost limitations imposed by Public Law 685, but they are eligible for accomplishment under Public Law 566, subject to approval by the Senate Agriculture and Forestry Committee and the House Agriculture Committee. The latter three projects are described individually in paragraphs 186 to 189 below. Pertinent data on the remaining 36 projects are given in table VII-1. The location of each small control project is shown on plate 9 bound at the end of the text.

143. General characteristics of the small control projects. The small control projects are proposed primarily for flood control. As indicated in table VII-1, these 39 projects as now proposed will have a total of 40,400 acre-feet of short-term storage and 2,020 acre-feet of inactive long-term storage for the accumulation of sediment. However, water supply storage may be included as a purpose in these projects if local interests so desire at the time detailed studies are undertaken. Inclusion of such storage in a project to be accomplished under Public Law 685 would be in accordance with the provisions of the Water Supply Act of 1958. Should the inclusion of water supply storage cause the project estimate to exceed the federal funds expenditure limitation imposed by Public Law 685, local interests would be required to make a lump sum payment of the amount in excess of the limit before initiation of construction. Where water supply storage is included as a purpose in projects developed under Public Law 566, it would be necessary for the local interests to obligate themselves for the payments of the total cost of the water supply features of the structure. There are no provisions under Public Law 566 for the local interests to defer payment for water supply development, and therefore the total amount would have to be arranged for prior to initiation of construction. The overall effectiveness of the 39 small control projects in reducing flood damages and the extent of recreation opportunities to be provided at the Parkside, Swiftwater and Jim Thorpe Projects are discussed in the following chapter.

144. OTHER PROGRAMS FOR LAND AND WATER USE. The optimum development of the water resources of the basin depends not only on impoundments but also upon the application and extension of a variety of land and water use programs. Such programs tend to satisfy local needs and reduce widespread regional needs for products and services of water resources. In most instances these programs have been proposed by those public and private agencies

contributing to the various fields of water resource development considered in this investigation and usually can be pursued as local applications of active continuing programs. Their role in the development of the water resources is in the satisfaction of those needs that are left unsatisfied by control projects because of physical, economic or geographic constraints. These programs often depend on expensive and sustained action by local interests and it would be presumptive to hazard assessments of their costs, extent of applicableness or effectiveness. Nevertheless the programs discussed in the paragraphs below are considered worthwhile features of the comprehensive plan for the development of the water resources of the Delaware River Basin.

145. Other programs for reduction of flood losses. Portions of the needs for relief from flooding and overland runoff reside in the uppermost headwater areas and the intermediate upstream areas of the basin. These needs, because of economic and geographic limitations, often remain unsatisfied by major control structures on the principle watercourses. No plan for the control and utilization of all surface water resources of the basin would be properly determined without due consideration of the needs in these areas. The importance of this segment of the water control is attested by the magnitude of agricultural flood damages which ranged from five to twelve thousand dollars per square mile on small watersheds in the 1955 flood. As indicated above, small control structures offer potentials for the satisfaction of these needs and have been studied as a feature of this investigation. In addition to the 39 small reservoirs selected as elements of the plan of development, watershed associations are actively planning small control measures for a number of intermediate upstream areas. Approved plans are in various stages of activation in five tributary watersheds as indicated in paragraph 101 above.

146. The land management programs of the Department of Agriculture are generally the most effective means of alleviating damages from overland flows in the uppermost headwater areas of the basin. In assessing these needs that Department in appendix K, established the extent of land areas currently in use in eight standard land capability classes and indicated the nature of conservation needs for each class. For example, there are about 1,750,000 acres of Class III lands in the basin suited primarily to cultivation. These lands are moderately sloping or wet lands, and the indicated conservation needs are strip cropping, terraces and drainage. The extent and indicated management measures for the various classes of land capabilities in the basin are shown in table VII-2. Although land management programs are active in the basin, much remains to be done to assess the effectiveness of indicated measures, to establish an integrated basinwide program and to implement such a program to accomplish optimum control of

TABLE VII-2

CURRENT DISTRIBUTION OF LAND USE BY CAPABILITY CLASSES

Land Class	Use Suitability	Characteristics	Conservation Needs	% in Basin	Areas in Use (1,000 acres)					
					Cropland	Pasture	Woodland	Idle	Urban	Total
I	Cultivation	Level, well drained	No special problems	3.2	151.1	19.9	60.1	13.9	12.6	257.6
II	Cultivation	Gently sloping, good drainage	Strip crops, simple management	21.5	1,095.4	162.3	354.5	124.1	25.4	1,761.7
III	Cultivation	Moderately sloping or wet land	Strip crops, terraces drainage	21.4	841.6	156.4	609.6	126.5	15.7	1,749.8
IV	Hay or grass	Moderately steep, eroded or wet	Erosion protection, drainage	8.7	221.3	30.7	415.3	31.6	8.8	707.7
V	Pasture, forest, wildlife	Nearly level, often wet or stony	Maintenance of cover		-	-	Very little within basin	-	-	
VI	Pasture, forest, wildlife	Steep slopes, eroded, stony or wet	Cover, forest and habitat management	14.2	102.7	49.8	974.4	27.9	5.0	1,159.8
VII	Timber, recreation, wildlife	Steep slopes, eroded, stony or wet	Forest and habitat management	19.2	55.7	27.6	1,448.6	33.9	2.6	1,568.4
VIII	Recreation, wildlife	Steep slopes, very rocky, waste, marshes	-	2.0	2.4	0.8	126.4	33.3	3.4	166.3
Unclassed *	-	-	-	9.8	-	-	-	119.7	678.7	798.4
TOTAL				100.0	2,470.2	447.5	3,988.9	510.9	752.2	8,169.7
%				100.0	30.2	5.5	48.8	6.3	9.2	100.0

* Cities, roads, water and other.
Data from Table 12, Appendix K, rounded to nearest 0.1 1,000 acres

the overland flows in the basin.

147. Reforestation is cited by the Department of Agriculture as a land management measure. With programs to control cuttings and forest fires, encourage natural growth and replace low value species by high quality future stands, benefits would be realized in the control of flood runoff and the enhancement of timber resources. About one-half of the land area of the basin is occupied by forests of which one-fourth contains stands of marketable timber.

148. Controlled use of the flood plains of the basin provides excellent potentials for the alleviation of flood damages. Included in programs of this type are such measures as prevention of channel encroachment, zoning to regulate development and reconstruction in the flood plains, adjustments in the occupance of lands and structures subject to flooding, and evacuation of the flood plain either on a permanent basis to provide for parks and other developments not susceptible to serious damage by flooding, or on a temporary basis by flood warning arrangements. Programs to control the use of the flood plains would be entirely feasible in some areas and, as indicated in appendix Q, data for use in planning the programs are available. The effective application of any or all of the possible measures to control the use of the flood plains will require that local interests initiate and administrate such programs. Zoning and similar devices for controlling flood plain developments come under the general category of policing powers, delegated by the Constitution to the States and, in turn, usually delegated to counties, townships and municipal governments. In the Delaware River Basin this power is delegated by the States of New York, New Jersey and Delaware, and the Commonwealth of Pennsylvania to their various subdivisions. New York, New Jersey and Pennsylvania have specific statutes that allow municipalities to incorporate flood plain zoning provisions in municipal zoning ordinances. In Delaware the Attorney General's office could find no authority competent to act in the public interest in flood plain zoning. Pennsylvania and New Jersey have enacted and are enforcing laws that contain channel encroachment provisions.

149. Programs to control the use of flood plains appear particularly applicable at local communities where local protection works were found to be economically infeasible at this time. Local flood damage centers that were studied for possible flood protection measures are listed in table VII-3. In most of these cases relatively costly local protection works were found to be economically infeasible and unless the community is located in damage reaches downstream from proposed control projects or is

TABLE VII-3

LOCAL FLOOD DAMAGE CENTERS

Locality	Stream	Area Flooded Flood	Acres	Remarks
Margaretville, N. Y.	E.Br. Delaware R.	Nov. 1950	100	a,
Rockland, N.Y.	Beaver Kill	Nov. 1950	40	a,b
Roscoe, N.Y.	Willowemoc Cr.	Nov. 1950	65	a,b
Livingston Manor, N.Y.	L. Beaver Kill & Willowemoc Cr.	Nov. 1950	40	a,b
South Sterling, Pa.	Wallenpaupack Cr.	Aug. 1955	10	a,c
Newfoundland, Pa.	Wallenpaupack Cr.	Aug. 1955	50	a
Greentown, Pa.	Wallenpaupack Cr.	Aug. 1955	10	b
Tusten Township, N. Y.	Ten Mile River	-	-	a
Milanville, Pa.	Calkins Cr.	-	-	a,c
Liberty, N.Y.	Mongaup R.	-	-	a,b
Port Jervis, N.Y.	Delaware R. & Neversink R.	Aug. 1955	50	b
Claryville, N. Y.	Neversink R.	-	-	a
Wurtsboro, N.Y.	Wilsey Brook	-	-	a,c
Sullivan County, N.Y.	Sheldrake Stream	-	-	a
Westbrookville, N.Y.	Basher Kill	-	-	a
Haven, N.Y.	Basher Kill	-	-	a
Godeffroy, N.Y.	Neversink R.	-	-	a,b
Port Jervis, N.Y.	Hollow Brook	-	-	a
Milford, Pa.	Saw Kill Cr.	-	-	a,b
Branchville, N.J.	Culver Cr.	-	-	a
Newton, N. J.	Paulins Kill	Aug. 1955	20	b
Blairstown, N.J.	Paulins Kill	Aug. 1955	70	a
Belvidere, N.J.	Delaware R. & Pequest R.	Aug. 1955	50	a
Easton, Pa.	Delaware R. & Lehigh R.	Aug. 1955	265	b
Phillipsburg, N.J.	Delaware R.	Aug. 1955	180	b
Canadensis, Pa.	Brodhead Cr.	Aug. 1955	40	b
Tannersville, Pa.	Pocono Cr.	Aug. 1955	20	b
Lehighton, Pa.	Lehigh R.	Aug. 1955	35	b
Bowmanstown, Pa.	Lehigh R.	Aug. 1955	15	a
Palmerton, Pa.	Lehigh R.	Aug. 1955	10	a
Slatington, Pa.	Lehigh R.	Aug. 1955	3	b
Walnutport, Pa.	Lehigh R.	Aug. 1955	5	b
Treichler, Pa.	Lehigh R.	Aug. 1955	5	b
Catasauqua, Pa.	Lehigh R.	Aug. 1955	25	b
Freemansburg, Pa.	Lehigh R.	Aug. 1955	60	a
Bath, Pa.	Monocacy Cr.	Aug. 1955	15	b
Riegelsville, Pa.	Delaware R.	Aug. 1955	100	b
New Hope, Pa.	Delaware R.	Aug. 1955	80	b
Yardley, Pa.	Delaware R.	Aug. 1955	150	b
Trenton, N.J.	Delaware R.	Aug. 1955	250	b
Hamilton Township, N.J.	Assunpink Cr.	-	-	e
Burlington, N.J.	Delaware R.	Aug. 1955	580	b
Bensalem Township, Pa.	Neshaminy Cr.	-	-	a
Chalfont, Pa.	Neshaminy Cr.	Aug. 1955	55,	b
Newportville, Pa.	Neshaminy Cr.	Aug. 1955	60	b
Lumberton, N.J.	Rancocas R.	-	-	a,e
Tamaqua, Pa.	L. Schuylkill R. & Wabash Cr.	Aug. 1955	95	b
Kutztown, Pa.	Sacony Cr.	Aug. 1955	175	b
Shoemakersville, Pa.	Schuylkill R.	-	-	a,b
Reading, Pa.	Schuylkill R.	Aug. 1955	130	b
Birdsboro, Pa.	Schuylkill R.	Aug. 1955	10	a
Pottstown, Pa.	Schuylkill R.	Aug. 1955	250	b
Sellersville, Pa.	Perkiomen Cr.	-	-	a,b
Norristown, Pa.	Stony Cr.	Aug. 1955	85	a,b
Norristown, Pa.	Schuylkill R.	Aug. 1955	40	b
Norristown, Pa.	Saw Mill Run	Aug. 1955	70	b
Whitemarsh, Pa.	Wissahickon Cr.	-	-	b,d
Westville, N.J.	Big Timber Cr.	-	-	a,e
Upper Darby, Pa.	Naylor's Run	-	-	e
Darby, Pa.	Darby Creek	-	-	e
Upland, Pa.	Chester Creek	-	-	e
Pomeroy, Pa. (Chester Co.)	Buck Run	-	-	a
Eddystone, Pa.	Crum Creek	-	-	e
Downingtown, Pa.	E. Br. Brandywine Cr.	Aug. 1955	80	c,d
Coatesville, Pa.	W. Br. Brandywine Cr.	Aug. 1955	90	c,d
Wilmington, Del.	Little Mill Cr.	July 1952	200	f

All areas studied after 1955 flood.

a. Studies based on questionaries and field reconnaissance indicated insufficient flood damages to warrant detailed consideration of costly improvements.

b. Local flood damage problems evaluated in comprehensive survey and taken into account in defining plan of development.

c. Flood protection works provided or proposed by the State.

d. Flood protection works provided or proposed under PL 566 or PL 685.

e. Flood problems arise from local channel encroachments, local encroachment on tidal areas or inadequate local storm drainage.

f. Being studied for possible accomplishment under PL 685 (as of Sept. 1960).

protected by measures provided by State or local interests, the local flood problems will remain substantially unchanged under the proposed plan of development. Each of these localities may profit by the application of local programs to control the occupance and use of the flood plain in its local area. In accordance with Section 206 of the Flood Control Act of 1960, the Corps of Engineers, may upon request of a state or responsible local government agency, provide data and information which will assist in planning adequately for flood plain use in their communities.

150. Other programs to satisfy water needs. The major control projects were designed to satisfy, to year 2010, the estimated demands for supplies of water for all purposes within subareas of the water service area. However, practical and economic considerations will result in those metropolitan centers, communities, industries and other riparian users conveniently located with respect to the reservoirs and augmented streamflows being the principal beneficiaries of the water supply features of the plan of development. The small control projects discussed earlier in this chapter should be considered, at the time detailed studies are made, as possible partial solutions to local water supply problems in some areas. Rural users and small communities will continue to rely mainly on ground-water sources at least until such time as the quality of surface waters or the distribution of centrally treated supplies of surface waters makes their use convenient and economical for the rural users. Under these conditions and with a view to assuring an equitable supply of water to all users in the future, it is imperative that specific programs for the controlled use and conservation of the basin's water resources and preservation of their quality be vigorously administered by local interests in the basin.

151. In 1955 ground-water resources were used to satisfy 440 mgd or about 15 percent of the water needs (exclusive of cooling water for thermal-electric generation) in the basin. In its inventory of the ground-water resources of the basin, as reported in appendix N, the U. S. Geological Survey found that ground-water suitable for most uses may be developed, at least in small quantities, almost anywhere in the basin. In the Coastal Plain large quantities of fresh water can generally be developed except near the ocean and Delaware Bay, and except as influenced by the inland extension of salt water in certain aquifers. The unused ground-water resources in the Coastal Plain were estimated at about 800 mgd that are susceptible of economic use. The potential ground-water supply in the Appalachian Highlands was estimated at 3,900 to 4,900 mgd. The U. S. Geological Survey in appraising this supply indicated that only a small fraction of this potential supply can be developed feasibly. In many places wells developed

in permeable deposits near streams may induce recharge at rates far greater than the natural recharge rates and development of large supplies in such cases would be at the expense of stream-flow, at least until the withdrawals are returned eventually to the stream. In the estimates of gross and net water requirements reported in appendix P, about 1,400 mgd, or eleven percent, of the requirements at year 2010 for seven water problem areas in the basin and coastal region, was assumed to come from ground-water supplies. This represents virtually all ground-water resources presently considered available for economic use in the seven water problem areas. The extent of this projected ground-water usage focuses attention on the need, at an early date, for basinwide programs for continuous accumulation of complete data on current ground-water usage; for rigid control of the magnitude and geographic distribution of ground-water withdrawals; and for augmenting these resources, where the geologic formations permit, by artificial ground-water recharge, subsurface storage of surface water excesses, and similar measures. The U. S. Geologic Survey has been engaged actively, in cooperation with the States, in the collection of ground-water data, but expansion of these activities will be required in the future as water uses increase in the basin. The other programs needed in connection with ground-water are presently considered to be in the area of State responsibility, and their extent and effectiveness rest with that level of government.

152. The problem of deficient natural supplies of surface and ground-waters in the southern basin areas adjacent to Delaware Bay and in the Coastal Plain may some day be solved by the desalting and purification of sea water or brackish water. Present minimum costs of such processes are many times the cost of providing fresh water by impoundments in the Delaware River Basin ($0.03 per 1,000 gal.). Conventional distillation processes today can desalt sea water at a cost of $2.00 - $3.00 per 1,000 gallons. Recent improvements in desalting techniques are expected to reduce this cost to $1.00 per 1,000 gallons. Membrane processes have been demonstrated capable of producing fresh water from brackish water (4,000 ppm dissolved solids) at costs ranging from $0.30 to $0.80 per 1,000 gallons. Such plants have been designed and installed with capacities up to 2.5 million gallons per day. The office of Saline Water Conversion, of the U. S. Department of the Interior, has reported world-wide inventories of progress in this field in its series of Research and Development Progress reports.

153. <u>Programs to preserve water qualities</u>. As discussed in paragraph 126 above, the waters of the Delaware River below Trenton receive tremendous waste loads. In the reach of the river from Trenton to Wilmington, the U. S. Public Health Service lists in appendix C sixteen municipal waste disposal facilities that served in 1958 a total population of 2,874,000, or more than 40 percent of the total population of the basin. These facilities discharged to

the river in 1958 an average daily flow of 365 mgd carrying an estimated pollution load equivalent to a population of 2,250,000. Because of pollution control measures, the pollution loads in this reach have been steadily decreasing since 1940 in spite of an increasing population during that period. However, the pollution load discharged to the river in 1958 provides opportunity for much improvement in the field of pollution load removal. The present level of the overall removal of the pollution load to the estuary, the Public Health Service reported in appendix C, is about 32 percent including discharges of raw and treated municipal sewage. In projecting the pollution loads as discussed in paragraph 126 above it was anticipated that the increased interception of waste and increased efficiency of treatment will increase the level of pollution load removal to 50 percent at year 1980 and 70 percent at year 2010. To achieve such levels of removal increasing emphasis will need to be placed on sewage treatment and sewage treatment research. It is apparent that acceptable water qualities in the basin will depend on a continued and vigorous program to increase waste removal efficiencies to assure a 70 percent removal of future raw pollution loads.

154. Water conservation programs. The general water use habits of the people of the basin and water service area have evolved from a long history of bounteous supplies of high quality water available to the individual or corporate users for the taking. The exercise of strict water conservation practices possibly would serve to prolong the current era of reasonably adequate water quantities and delay the time of constructing extensive and costly developments to augment raw water supplies. Many water conservation practices have been proven feasible in water deficient areas. Probably the most effective for use in this area would be internal recycling of water used by industry and increased repetitive use of water as it flows from the headwater levels of the basin to the sea. In both of these possibilities the problems of water pollution may act to set constraints on the practical limits of their application. However, it is apparent that the practice of conservation measures in the use of water has much to offer in an area such as the Delaware River Basin where projected population and industrial activity foretell dwindling surpluses of raw water. Programs by local interests to encourage the acceptance and practice of all possible water conservation measures should be features of any plan to develop the water resources of the basin.

155. Other programs to provide recreation opportunities. Appendix I contains an inventory of all non-urban public park and recreation developments in the Delaware River Basin. These include 96 state and county parks, 15 state forests, 99 hunting and fishing areas, 9 state and county historical sites, 3 forest-park reservations, 3 national wildlife refuges, one Federal reservation and one Federal historic site. This reflects the present

capacity of recreation developments in the basin including recreation developments similar to those proposed in connection with water storage and control projects.

156. Within the Pennsylvania portion of the Delaware River Basin there are 13 state parks with a total of 37,231 acres; 1 state forest of 71,387 acres on which are located four separate recreation areas; 29 state game areas with a total of 110,660 acres; 8 public fishing areas totalling 1,159 acres; and 4 historical sites with a total of 260 acres. The parks are fairly well distributed with regard to population centers, whereas the state forest and fish and game areas are located, for the most part, in the middle and upper part of the basin. In addition, there are 213,579 acres of cooperative farm-game program lands open for public hunting.

157. Existing park and recreation developments within the New Jersey portion of the basin include 15 state parks ranging in size from 12 acres to 10,935 acres, with a total of 17,882 acres; 8 state forests totalling 56,177 acres; 2 forest-park reservations of 96,000 and 6,200 acres; and a total of 87,027 acres of public shooting and fishing areas. New Jersey also administers 18 historic sites throughout the state.

158. Existing park and recreation developments within the entire state of Delaware include 3 state parks with a total of 1,079 acres; 6 state forests totalling 4,709 acres; 29 wildlife and fishing areas with a total of 14,858 acres, of which 5,000 acres are lands of the Chesapeake and Delaware Canal, and 2,650 acres of state beach lands extending 14.6 miles along the shore; and one historic site. These recreation areas are administered by five different agencies of the state government.

159. Within the New York portion of the basin there are no state parks; there are, however, 234,610 acres in the Catskill Forest Preserve, one game management area and 57 miles of stream easement wholly or partially within the confines of the basin area which are used to some extent for nonurban outdoor recreation.

160. Appendix I contains proposals relating to the expansion and further facility development of 15 state parks in New Jersey, 10 state parks in Pennsylvania, state forest camps in New York, and three state parks in Delaware. This proposal provides for a portion of the recreation needs of the basin not met by the recreation development proposed in connection with water control projects. Appendix I also contains proposals relating to the planning and development of additional park and recreation areas in the basin states, namely one state park in New Jersey, three in Pennsylvania and four in Delaware and three historical sites in the latter state. It is also proposed that certain lands in Pennsylvania, New Jersey and Delaware be acquired as recreation reserves to be developed at some future period when the need

arises. The proposed new recreation and historical areas and the proposed recreation land reserves within the basin boundaries are listed in table VII-4 together with available data on acreage and estimated annual visitation. The recreation land reserves are proposed for development after year 1980. The proposed new areas and reserves related primarily to fresh water resources of the basin are marked by single asterisks. The reserves listed in table VII-4 are in addition to the recreation reserves based on indirectly related recreation potentials at major control projects described in paragraph 140 above.

161. Programs to enhance fish and wildlife resources. General guide-lines by which the more important fish and wildlife resources of the Delaware River Basin can be protected and improved are presented in appendix J. The more important elements of these guidelines concern the fresh water fisheries, marine fisheries, anadromous and catadromous fishes, and wildlife.

162. With regard to fresh water fisheries, appendix J points out that the elements necessary for the protection and/or improvement of the fresh water resource would include acquisition of public fishing rights, the development of access facilities, stream habitat improvement, reclamation and a stocking of selected trout streams throughout the basin. Also necessary is the development of additional access and the improvement of fishing waters presently open to public use, including some of the reservoirs and major streams of the basin. The construction and management of small water impoundments specifically for fishing, and of large impoundments capable of producing good fishing, is included in the general guidelines. Other features are the use of all fishable waters in parks for maximum feasible public use; installation of stream improvement devices on certain sections of streams altered by small dams; elimination of acid, culm and silt from upstream basin waters; and the reduction of water contamination from domestic, municipal and industrial wastes. Also considered among the important elements of necessary steps to the protection and improvement of the fishery resources are the inclusion of access, sanitation, parking and boat launching developments for public fishing at all dam and reservoir projects included in the plan of development, and the provision of water releases below each project to meet volume and temperature requirements necessary to protect and enhance, if possible, the fishery values downstream. Other elements include acquisition of public fishing rights, and the development of access and public facilities along streams in the basin to mitigate the loss of stream fisheries expected as a result of the construction of dam and reservoir projects included in the plan of development. As mitigating measures for loss of stream fishery values in connection with the Tocks Island Dam and Reservoir, appendix J also proposes the construction of project outlet works that will permit releases from various levels of the reservoir, with provisions for coordination between project operators and appropriate fish conservation agencies

TABLE VII-4

PROPOSED NEW RECREATION AREAS AND RECREATION LAND RESERVES WITHIN DELAWARE RIVER BASIN

State	Area	Acreage	Estimated Average Annual Visitation
	PROPOSED NEW RECREATION AND HISTORICAL AREAS		
Delaware	* Lums Pond	1,350	350,000
	* Killen-Coursey-McCauley Ponds	3,600	300,000
	Delaware Dunes	1,000	100,000
	Churchman's Marsh	1,500	15,000
	** Cooch's Bridge	15	1/
	** Buena Vista	15	1/
	** McDonough House	2	1/
Pennsylvania	* Baron Hills	3,500	1,000,000
	* Green Lane	2,000	1,500,000
	PROPOSED RECREATION LAND RESERVES		
Delaware	Cape Henlopen	2,000	1/
	Woodland Beach	1/	1/
	* Becks Pond & Sunset Lake	50 2/	1/
	* Voshell Pond	31	1/
	* Red Mill Pond	150 3/	1/
	Augustine Beach	1/	1/
	* Smalley's Pond	60 3/	1/
New Jersey	Raritan Arsenal	1/	1/
	W. Cape May Beach	1/	1/
	Cox Hall Creek	1/	1/
Pennsylvania	Shohola Falls	12,000	1/
	* Warner Lakes	3,200	1/
	* Reservoir WA-5A	175 3/	1/
	Jacobsburg Tract	500	1/

1/ Data not available.
2/ Water surface area for Becks Pond only.
3/ Water Surface area only.
* Related primarily to fresh water resources.
** Historical areas.

throughout the project life. Special studies are proposed during planning and construction, and thereafter if necessary, to determine appropriate fish passage measures to offset the barrier effects on migration of fishes.

163. Important elements proposed for the protection and improvement of the marine fishery resource include the initiation of a coordinated Federal-non-Federal comprehensive survey of the commercial and recreational uses of these fishery resources; an estuarine research program, including a study of fin fishes and shell fishes; the development of public boat launching areas; and public fishing access areas along the Delaware Bay shore.

164. Protection and improvement of wildlife resources of the Delaware Basin, as proposed in appendix J, include legislation and education activities, and administrative action and habitat management for the deer populations. Similar proposals are made with regard to wild turkey, farm game resources, and upland game resources. The acquisition and development of public hunting areas, the expansion and development of small marshes and ponds, the preservation of wetlands to conserve and enhance waterfowl and fur animal resources are also proposed. The improvement and preservation of marshland habitat in the Coastal Plains section of the basin is of special consideration. Mentioned as units deserving consideration in this respect are. 1,300 acres of the Crosswicks Creek-Trenton Marshes; 250 acres of fresh tidal marsh and water along Pennsauken Creek; 700 acres of marsh along Rancocas Creek; 180 acres of mudflat and shoal at Fish House Cove; 250 acres of marsh at Hermesprota Creek; 1,500 acres of marsh, swamp and shoal in the Monds Island-Rapaupo Creek-Chester Island area; 960 acres of fresh tidal marsh on Raccoon Creek; 1,200 acres on Oldman's Creek; and 850 acres along the Christina River, including 400 acres at Churchman's Marsh. To improve public water fowl hunting opportunities there are also included the development of access facilities; the development of feasible measures for the disposal of spoil from navigation works which will spare the better habitat and offset destruction through use of spoil to improve, replace and/or create water fowl habitat; the continuation and expansion of efforts to adapt insect control and waterfowl development methods that are mutually acceptable and beneficial; and the coordination of the development of waterfowl habitat with road building activities. Important elements that would mitigate losses of existing wildlife habitat and/or public hunting areas as a result of the construction of dams and reservoirs, include the acquisition of land and improvement of habitat thereon for single-purpose game management and public hunting use throughout the basin, together with the replacement of certain facilities serving game administration needs. The Fish and Wildlife Service in assessing

the overall effects of the proposed plan of water resource development on the fish and wildlife resources of the basin could foresee the need for preconstruction studies to examine in detail these effects. The Service estimated the cost of these studies at $65,000.

165. <u>DESCRIPTIONS OF MAJOR CONTROL PROJECTS PROPOSED FOR MULTIPLE-PURPOSE DEVELOPMENT PRIOR TO YEAR 2010</u>. The eleven major control projects proposed for complete development prior to year 2010 are described in the following paragraphs. The projects included in this category and the order of the individual project descriptions are as follows:

Hawk Mountain	Trexler
Prompton (Modification)	Maiden Creek
Tocks Island	Blue Marsh
Bear Creek (Modification)	Newark
Beltzville	Christiana
Aquashicola	

166. <u>Hawk Mountain Project</u>.

a. <u>Description</u>. The Hawk Mountain Project is proposed for multiple-purpose development to provide supplies of water, for production of hydroelectric power, and for recreation purposes. Hawk Mountain dam site is located on the East Branch of Delaware River about 2-1/2 miles east and upstream from Hancock, N.Y. (See plate 10.) The contributing drainage area is 440 square miles exclusive of 372 square miles which contributes to Pepacton Reservoir, created by Downsville Dam and constructed as a part of New York City's water supply system. The proposed earth and rock fill dam will rise 177 feet above the river bed with a top length of 1,900 feet. A side channel spillway with a 550-foot length of crest at elevation 1,082 will be cut into the left abutment to convey water through a chute and stilling basin to the river channel below the dam. The concrete conduits will be constructed on rock along the left bank of the river with gates and a control tower at the upstream end. After serving as diversion conduits during construction, a steel penstock will be installed in each conduit from the center of the dam to the powerplant. The powerplant, located about 450 feet below the axis of the dam on the left bank, will contain two turbines each with a rating, at best head, of 15,000 horsepower and each direct-connected to a 10,500 kilowatt generator. The step-up substation would be located adjacent to the powerhouse on a raised section of the toe of the main embankment. Storage allocations for the Hawk Mountain Project are 60,000 acre-feet of inactive long-term storage, primarily for hydropower, to elevation 1,008, and 233,000 acre feet of active long-term storage for supplies of water, power and recreation to elevation 1,082. The reservoir, at elevation 1,082, would extend upstream about 22 miles to a point about one-mile downstream from the town of Downsville, N. Y. Relocation of about

21-1/2 miles of State Highway Routes 17 and 30, and the communities of Fishs Eddy and East Branch will be necessary. A total of 7,800 acres would be required for the complete development. Of this area 5,800 acres would be for the construction of the project, and 2,000 acres would be for directly related recreation. The total estimated cost of the Hawk Mountain Project is $42,000,000 which includes specific costs for power and recreation of $5,080,000 and $1,420,000 respectively. The estimated specific recreation costs include $778,000 for recreation facilities and $637,000 for recreation lands, both of which are in the category of directly related recreation. Financing of the separable costs for hydropower for this project at the private financing rate applied in deriving alternate thermal power costs, resulted in the hydropower feature being unfavorable. In view of the long range completion schedule and the sound water supply value, however, the hydropower feature is retained in the Hawk Mountain Project as an added though marginal feature. As for all non-Federal interest projects the hydropower feature would be given detailed study by local interests when planning for construction.

b. Functions:

(1) Supplies of water. Use of 233,000 acre-feet of active long-term storage at the Hawk Mountain Project will result in a net yield of 580 cubic feet per second at the site. The effective augmention to the yield of the Tocks Island reservoir would be 465 cubic feet per second. This augmention of flow would contribute to the satisfaction of the water needs of the Trenton-Philadelphia area for the projected 50-year period under consideration.

(2) Power. The hydroelectric powerplant at the Hawk Mountain Project would have an installed capacity of 21,000 kilowatts, a dependable capacity of 11,000 kilowatts and would produce an average of 93.8 million kilowatt-hours of energy annually.

(3) Recreation. The Hawk Mountain Project would provide recreation capacity to accommodate about 187,000 visitors annually. Facilities will be provided for one-day outings as required. The necessary roads, trails, sanitary facilities and water supplies will be provided. Hunting will be permitted in appropriate season and under reasonable regulation to assure public safety. Operation of the project will consider the streamflow requirements of stream fisheries and the management of the impounded water for lake fisheries as a coordinated element for full realization of the recreation potential of the project.

167. Prompton Project.

a. Description. The Prompton Project, now under construction as a single-purpose flood control project (with incidental recreation use) and scheduled for completion in 1960, would be modified for multiple-purpose use to provide supplies of water and recreation benefits as well as the presently designed flood control function. The Prompton dam is located in the valley of Lackawaxen River about 1/2 mile upstream from the confluence of Waymart Branch with the river, and about 4 miles west of Honesdale, Pennsylvania (See plate 11). The dam presently under construction, which controls 60 square miles of drainage area, will be 1,300 feet long and 140 feet high. The spillway, which is cut into the hill around the right (west) end of the dam, is 50 feet wide. A conduit has been built along the right bank to carry limited amounts of flow. This conduit has an uncontrolled inlet at elevation 1,125 in the reservoir pool and a stilling basin at the downstream end.

b. Storage allocations for the modified Prompton Project, based on the most economical modification of the existing dam and reservoir, would be 3,400 acre-feet of inactive long-term storage to elevation 1,125; 28,000 acre-feet of active long-term storage for supplies of water and recreation use to elevation 1,180; and 20,300 acre-feet of short-term storage for flood control to elevation 1,205. Comparative data on the present and proposed modified project at this site are as follows:

	Present Project	Proposed Modified Project
Capacities, in acre-feet		
Flood Control	20,300	20,300
Water Supply	0	28,000
Inactive	3,400	3,400
Elevation Top of Pool, in feet, m.s.l.		
Flood Control	1,168.1	1,205 1/
Water Supply	-	1,180
Inactive	1,125	1,125

1/ Spillway crest elevation

The long-term storage requirement and operation for multiple-purposes dictate the following additions or modifications to the structures presently under construction:

(1) A control tower with gates and a service bridge to control releases from the reservoir.

(2) A blanket of impervious material on the valley wall and floor upstream from the dam.

(3) Widening of the spillway to 250 feet.

(4) Clearing of reservoir land and relocating roads subject to inundation.

c. The reservoir to be created by long-term storage up to elevation 1,180 will extend about 4 miles upstream. The reservoir for short-term storage would rise to about the same level as that for the structure now under construction and hence would require procurement of flowage easement on only 30 acres of land in addition to that already under easement. The modified Prompton development will include a total area of 2,055 acres. In addition to the 730 acres required for construction of the project, 925 acres would be required for directly related recreation and 400 acres for indirectly related recreation. The total estimated cost of the modified multiple-purpose project, excluding $387,000 for indirectly related recreation, is $8,050,000, which is made up of $3,700,000 estimated as the cost of the flood control project now under construction and $4,350,000 estimated as the cost for the modifications previously discussed. Of this amount, $427,000 are included as the estimated specific costs of directly related recreation. The directly and indirectly related recreation costs are composed of the following:

Item	Estimated Specific Recreation Costs	
	Directly Related	Indirectly Related
Land	$144,000	$ 62,000
Facilities	283,000	325,000
	427,000	387,000

The cost of land now being acquired by the Commonwealth for recreation purposes is included in these estimates of recreation costs.

d. Functions.

(1) Supplies of water. Use of 28,000 acre-feet of active long-term storage at the Prompton Project would result in a net yield of 57 cubic feet per second. This augmentation of flow will contribute to the satisfaction of the water needs of the Trenton-Philadelphia area for the projected 50-year period under consideration.

(2) Reduction of flood damage. Flood heights on the Lackawaxen River will be substantially reduced by the Prompton Project and the Edgar Jadwin dam and reservoir on Dyberry Creek, above Honesdale, Pennsylvania. The towns of Honesdale, located at the confluence of Dyberry Creek with the Lackawaxen River, and Hawley, located between the junctions Middle Creek and Wallenpaupack Creek with the Lackawaxen River, will obtain substantial relief from frequent and considerable flood damage. Several villages and seven townships located in the lower reaches of Lackawaxen River have residential, commercial, utility, highway and other developments on the flood plain, and experienced 1-1/2 million dollars in flood damage in 1955. Conversion of the Prompton Dam and Reservoir to a multiple-purpose development would preserve the flood control function of this project as originally authorized and flood reduction benefits will be unaffected by the proposed modification. Control

of flood waters by the Prompton and Edgar Jadwin Projects will reduce the river stages at Hawley, Pa. by about four feet for a flood of the magnitude experienced in 1955. Additional limited reduction of flood damage will accrue on the main stem of the Delaware River from the Prompton and Edgar Jadwin Projects.

(3) Recreation. The Prompton Dam and Reservoir Project would provide a total recreation capacity to accommodate a total of 156,300 visitors annually. Of these, 81,900 visitors annually are credited to the directly related recreation developments. Due to the lack of suitable terrain, recreation potential at this project is limited. However, lands suitable for day-use recreation are included in the plan of improvement. Necessary roads, trails, sanitary and administrative facilities will be provided. Hunting will be permitted in appropriate season and under reasonable regulation to assure public safety. Operation of the project will consider the downstream flow requirements for stream fisheries and the management of the impoundment for lake fisheries as a coordinated element for full realization of the recreational potential of the project.

168. Tocks Island Project.

a. Description. The Tocks Island Project is proposed for multiple-purpose development to provide supplies of water, flood control, production of hydroelectric power, and for recreation purposes. The Tocks Island dam site is located on Delaware River about 5 miles upstream from Delaware Water Gap and about 7 miles northeast of Stroudsburg, Pennsylvania. (See plate 12.) The site is at the upstream end of Tocks Island which is about 2-1/2 miles upstream from Shawnee-on-Delaware, Pennsylvania. The contributing drainage area is 2,912 square miles, exclusive of 915 square miles which contribute to the Neversink, Pepacton and Cannonsville Projects of the City of New York. The dam will contain about 3-1/2 million cubic yards of earth and rock, be 3,200 feet long, and rise 160 feet above the river bed to elevation 456. (See plate 13.) It will have a central impervious earth core extending into the foundation to a maximum depth of 30 feet below the base of the dam. Two 22-foot diameter conduits placed on rock along the left river bank will serve both as diversion conduits during construction and later as penstocks for production of power. At the downstream end of the conduits will be a powerplant with two turbine-driven generators of 23,000-kilowatt capacity each. All low level water releases will pass through the turbines or through a bypass channel from each penstock built into the powerhouse substructure. The step-up substation will be located adjacent to the powerhouse on a raised section of the toe of the main embankment. In addition to the conventional powerplant described above, a pumped-storage powerplant with provision for four reversible power turbine units of 91,500-kilowatt capacity each will be located upstream from the spillway and about 1,200 feet upstream from the centerline of the dam. The spillway cut into the left (New Jersey) abutment will have a concrete crest at elevation 395 surmounted by ten radial gates each 40 feet long and 35 feet high. The concrete lined spillway chute cut into rock will discharge water into a stilling basin downstream from the powerplant and from there into the river channel. An item has been included in the cost estimates for facilities for passing fish over the dam in the event preconstruction studies show the need for specific facilities for that purpose. Storage allocations for the Tocks Island Project, as determined from detailed planning studies, indicate 80,000 acre-feet of inactive long-term storage to elevation 356; 410,000 acre-feet of active long-term storage for supplies of water, power, recreation and other uses to elevation 410; and 275,000 acre-feet of short-term storage for flood control to elevation 428. The reservoir formed by this dam, up to elevation 428, will extend approximately 9 miles up Flat Brook and 37 miles up the Delaware River to Port Jervis, New York. It will necessitate the relocation of 27 miles of Federal Highway 209 as well as county roads, local roads, the community of Bushkill, Pennsylvania, parts of Dingmans Ferry, Pennsylvania, and a few buildings at Milford, Pennsylvania. The

town of Matamoras, Pennsylvania, at the upper end of the reservoir would be protected by a dike about 12,000 feet long and appurtenant outlet pipes, drains and pumping plants. The bridge on U.S. Route 6 to Tri-State, New York would be replaced. No railroad relocations will be required and there are no commercially valuable mineral deposits in the reservoir area. A total of 62,370 acres of land will be acquired for the complete development. In addition to the 14,800 acres required for construction of the project, 9,500 acres would be required for directly related recreation and 38,070 acres for indirectly related recreation. The total estimated cost of the Tocks Island Project, excluding $31,600,000 for indirectly related recreation, is $146,000,000 which includes specific costs for power and recreation of $66,200,000 and $18,300,000 respectively. The estimated specific costs for power include $12,300,000 for conventional power at the dam and $53,800,000 for pumped-storage type power facilities to be included in the overall development. The estimated specific costs for directly and indirectly related recreation include the following:

Item	Estimated Specific Recreation Costs: Directly Related	Estimated Specific Recreation Costs: Indirectly Related
Land	$ 8,080,000	$13,400,000
Facilities	10,200,000	18,200,000
	18,280,000	31,600,000

b. Functions.

(1) Supplies of water. Use of 410,000 acre-feet of active long-term storage at Tocks Island Project would provide a net yield of 980 cubic feet per second. This augmentation of flow would contribute to the satisfaction of the water requirements of the Trenton-Philadelphia area as indicated for the 50-year period under consideration.

(2) Reduction of flood damage. The 1955 flood damages in the reach from Tocks Island to Burlington, New Jersey, exceeded 85 percent of the total damages for the main stem of the Delaware River, and occurred principally at the damage centers of Easton, Riegelsville, New Hope, and Yardley, Pennsylvania; and Belvidere, Phillipsburg, Trenton and Burlington, New Jersey. The flood control storage provided at Tocks Island and other projects in the water control plan, would reduce, by system operation, the stage of the 1955 flood at Trenton by about 6 feet, based on the modified stage reflecting the regulation capacities of the Bear Creek, Edgar Jadwin and Prompton Projects. For the 1942 flood, the system flood control storage, including that at the Tocks Island Project, would result in a stage reduction of about 3.7 feet.

(3) Power. Operation of the Tocks Island Project for multiple-purpose use would support a conventional hydropower installation of 46,000 kilowatts, a dependable capacity of 20,000 kilowatts, and the average annual production of 281.5 million kilowatt-hours. In addition to the conventional power plant, advantageous physical conditions at the site permit the construction of a pumped storage power scheme with an installed capacity of about 366,000 kilowatts, a dependable capacity of 342,000 kilowatts and the average annual production of 732.0 million kilowatt hours.

(4) Recreation. The Tocks Island reservoir area would provide recreation capacity to accommodate 6,750,000 visitors annually of which 2,470,000 are credited to the directly related recreation use. The lands to be acquired for recreation would provide for public ownership of the shore area and would provide space for development of 10 major recreation areas. The outstanding scenic and recreation resources of the project would thus be preserved in public ownership. Various facilities would be provided for one-day outings as well as camping. Operation of the project would consider the fishing requirements of the impoundments; the flow requirements for the stream fisheries downstream from the dam; and, should facilities be provided for moving anadromous fish above the dam, consideration would be given to augmenting flows in the month of October for the purpose of moving young fish populations through the polluted zone of the river in the vicinity of Marcus Hook. Special studies would be pursued during later planning stages in order to determine this specific requirement. Hunting would be permitted during appropriate season and in accordance with reasonable regulation to assure public safety.

169. Bear Creek Project.

a. Description. The Bear Creek Project now under construction and scheduled for completion in 1961 is a single-purpose flood control project (with incidental recreation use) which would be modified for multiple-purpose development to provide supplies of water and recreational use as well as the presently authorized flood control. The earth and rock fill dam is located on Lehigh River 75 miles above its confluence with Delaware River and about 5 miles north of White Haven, Pennsylvania. (See plate 14). At this location the dam controls 288 square miles of drainage area. Comparative data on the present and proposed modified project at this site are as follows:

	Present Project	Proposed Modified Project
Capacities, in acre-feet		
Flood Control	108,000	108,000
Water Supply	0	70,000
Inactive	2,000	2,000
Elevation Top of Pool, in feet m.s.l.		
Flood Control	1,450 1/	1,481 1/
Water Supply	-	1,425
Inactive	1,300	1,300

1/ Spillway crest elevation

The proposed modifications to the dam now under construction to make it serviceable for long-term storage in addition to the present flood control storage will involve:

(1) Moving and raising the spillway crest 31 feet to elevation 1,481.

(2) Raising the dam to elevation 1,503.

(3) Adding 70 feet of concrete conduit to the downstream end of the outlet tunnel.

(4) Constructing new dikes and raising existing dikes north of the dam.

The modified dam will rise 263 feet above the stream bed and have a length of 3,500 feet. The spillway would be cut through rock to the north of the dam, and farther north a dike 4,600 feet long will fill a swale in the reservoir rim. Operation of three gates controls the flow through the outlet tunnel. The reservoir for long-term storage would have a maximum depth of 185 feet and would extend 7.0 miles up the Lehigh River and 4.0 miles up Bear Creek from the dam. This reservoir would necessitate the purchase of land to be inundated on which flood easements have already been taken and would require the acquisition of additional flood easements at

higher elevations. No economically valuable mineral deposits would be flooded and only one road along Bear Creek would require relocation in addition to those required for the presently authorized flood control project. A total of 3,950 acres of land would be acquired for the complete development. In addition to the 1,950 acres that would be required for construction of the project, 1,300 acres would be required for directly related recreation and 700 acres for indirectly related recreation. The total estimated cost of the modifications to the Bear Creek Project, excluding $875,000 for indirectly related recreation, is $8,990,000 which includes specific recreation costs of $595,000. The estimated specific costs of directly and indirectly related recreation include the following:

Item	Estimated Specific Recreation Costs	
	Directly Related	Indirectly Related
Land	$190,000	$102,000
Facilities	405,000	773,000
Total	595,000	875,000

The total cost of the project modified as proposed herein would be $20,100,000 which includes an estimated cost of $11,100,000 for the present project. Costs for indirectly related recreation are excluded from this estimated total cost.

b. Functions.

(1) Supplies of water. Use of 70,000 acre-feet of active long-term storage at the Bear Creek Project would provide a net yield of 196 cubic feet per second. This flow augmentation would contribute to the satisfaction of the water requirements of the Allentown-Bethlehem area and the Trenton-Philadelphia area as indicated for the 50-year period under consideration.

(2) Reduction of flood damages. The 108,000 acre-feet of presently authorized short-term storage would be included as the initial stage in the multiple-purpose development. This storage will be effective in alleviating flooding in the upper reach of the Lehigh River where damage is confined, primarily, to the towns of Jim Thorpe, Lehighton, Weissport, Parryville, Palmerton, and Bowmanstown, Pennsylvania. Below Lehigh Gap both the river and flood plain widen. Railroad alignments located in the flood plain together with 44 railroad and highway bridges spanning the Lehigh River are subject to recurring flood damage. The inundation of the Lehigh Navigation Canal, in the reach from Jim Thorpe to Easton, Pennsylvania, is accompanied by extensive flood damage. Damage centers in the reach from Lehigh Gap to Easton, Pennsylvania, include industrial and residential areas located in the vicinity of the towns of Northampton, Hokendauqua, Catasauqua, Allentown, Bethlehem, Freemansburg and Easton, Pennsylvania. Considerable flood stage reduction will be provided in these damage areas by operation of the short-term storage at the Bear Creek Project. The flood control storage has been preserved as previously authorized,

and flood reduction benefits will be unaffected by the proposed modification.

(3) Recreation. The Bear Creek Reservoir will provide recreation capacity for 250,000 visitors annually of which 101,200 are credited to the directly related recreation uses. The lands acquired for recreation will provide for public ownership of the desirable shore area and provide space for development of three recreation sites. Necessary facilities for one-day outings as well as camping would be provided. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impoundment for lake fisheries as a coordinated element for the full realization of the recreation potential of the project. Hunting would be permitted during appropriate season and in accordance with reasonable regulation to assure public safety.

170. Beltzville Project.

a. Description. The Beltzville Project is proposed for multiple-purpose development to provide supplies of water, flood control and recreation. The Beltzville dam site is located in the Pohopoco Valley about 0.3 mile upstream from the confluence of Sawmill Run and Pohopoco Creek and approximately 4 miles east of Lehighton, Pennsylvania. (See plate 15). The net contributing drainage area above this site is 75 square miles, excluding 22 square miles that contribute to the Wild Creek Reservoir, which supplies water to the City of Bethlehem, Pennsylvania. The earth and rock fill dam will extend for a length of 4,500 feet and rise 160 feet above the creek bed. Diversion flows and low level reservoir releases will pass through a conduit constructed on rock along the right side of the valley. A spillway will be constructed around the north end of the dam with the channel in bedrock. Flow from the spillway will discharge into Sawmill Run and thence back into Pohopoco Creek. Storage allocations for the Beltzville Project, as indicated by detailed planning studies, are 1,200 acre-feet of inactive long-term storage to elevation 525; 40,000 acre-feet of active long-term storage for supplies of water and recreation to elevation 615; and 27,000 acre-feet of short-term storage for flood control to elevation 641. The reservoir up to spillway crest elevation 641 will extend approximately 7 miles upstream. Relocation or improvement of about 4.7 miles of county road will be required. No railroads or communities are in the reservoir area and there are no workable mineral deposits. However, sections of two oil pipelines will require relocation, and power lines and water lines will require reinforcing where they cross the reservoir. During the planning studies for this project the Palmer Water Company submitted a report setting forth its needs for a continuous and permanent supply of water from Pohopoco Creek downstream from the dam site. The Company supplies municipal and industrial water in the vicinity of Palmerton, Pennsylvania and in accordance with Act 365 of the Commonwealth of Pennsylvania the Company has filed with the Commonwealth a statement showing its water withdrawals to be about 13 mgd with future needs estimated at 20 mgd. Arrangements will be made during construction and thereafter to release water as required to fully satisfy downstream water rights. A total of 2,413 acres of land will be acquired for the complete development. In addition to the 1,030 acres required for construction of the project, 723 acres would be required for directly related recreation and 660 acres for indirectly related recreation. The total estimated project cost, excluding $1,190,000 for indirectly related recreation, is $13,800,000 which includes $1,290,000 of specific costs for directly related recreation. The directly and indirectly related recreation costs include the following:

Item	Estimated Specific Recreation Costs Directly Related	Indirectly Related
Land	$411,000	$ 34,000
Facilities	876,000	1,153,000
Total	1,287,000	1,187,000

b. Functions.

(1) Supplies of water. Use of 40,000 acre-feet of active long-term storage at the Beltzville Project would provide a net yield of 80 cubic feet per second. This flow augmentation would contribute to the satisfaction of the needs of the Palmerton, Bethlehem and Trenton-Philadelphia areas during the 50-year period under consideration.

(2) Reduction of flood damage. The flood control storage at the Beltzville Project will contribute to flood stage reductions at the principal damage centers on Lehigh River below the confluence of that river with Pohopoco Creek. These damage centers are located at Bowmanstown, Walnutport, Northampton, Hokendauqua, Catasauqua, Allentown, Bethlehem, Freemansburg and Easton, Pennsylvania. Combined operation of the three new major flood control projects in the Lehigh River Basin included in the water control plan will result in a stage reduction of two feet at Bethlehem, Pennsylvania, for a flood similar to that experienced in 1955. This reduction is in addition to the effects of the Bear Creek Project.

(3) Recreation. The Beltzville reservoir will provide a recreation capacity for 500,000 visitors annually, of which 110,000 are credited to directly related recreation uses. The lands acquired specifically for recreation development will provide for public ownership of the shore area and space for development of five recreation sites. Facilities would be provided for one-day outings as well as camping. Hunting would be permitted in appropriate season and under reasonable regulation to assure public safety. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of lake fisheries as a coordinated element for full realization of the recreation potential of the project.

171. Aquashicola Project.

a. Description. The Aquashicola Project is proposed for multiple-purpose development to provide supplies of water, flood control and recreation. The Aquashicola dam site is located on Aquashicola Creek about 4-1/2 miles upstream from its confluence with the Lehigh River and about 3 miles east of Palmerton, Pennsylvania. (See plate 16). The site is about one mile downstream from the confluence of Buckwha Creek with Aquashicola Creek. The drainage area above this site is 66 square miles. The compacted earth fill dam would stretch approximately 2,000 feet across the valley with a concrete section and spillway 160 feet long founded on rock at the south end. The dam would rise 110 feet above a cutoff with maximum depth at 30 feet to control passage of water through the foundation. The top of dam would be 20 feet above the spillway crest. Outlet sluices through the spillway would provide for water releases. Diversion during construction would be made through low blocks in the spillway section. Storage allocations for the Aquashicola Project as indicated by detailed planning studies, are 1,000 acre-feet of inactive long-term storage to elevation 435; 24,000 acre-feet of active long-term storage for supplies of water and recreation to elevation 483; and 20,000 acre-feet of short-term storage for flood control to elevation 503. The reservoir at spillway crest elevation 503 would be 90 feet deep at the dam and extend five miles up Aquashicola Creek from the dam and six miles up Buckwha Creek. Relocation of an oil pipeline, a waterline, roads, 7.3 miles of the Chestnut Ridge Railroad, quarry equipment, rural residences and the community of Little Gap, Pennsylvania, would be required. The only commercial mineral deposit near the reservoir area is a sandstone quarry southeast of Little Gap, Pennsylvania. The reservoir does not inundate this quarry but some relocation of crushing and processing equipment would be required. Sand from this quarry is shipped by rail cars at the approximate rate of five cars per day. This constitutes the principal traffic on the Chestnut Ridge Railroad in the vicinity of the reservoir. A total of 2,150 acres of land will be acquired for the complete development. In addition to the 900 acres required for construction of the project, 770 acres would be required for directly related recreation and 480 acres for indirectly related recreation. The total estimated project cost, excluding $488,000 for indirectly related recreation, is $19,000,000, which includes $878,000 of specific costs for directly related recreation. The directly and indirectly related recreation costs include the following:

Item	Estimated Specific Recreation Costs: Directly Related	Estimated Specific Recreation Costs: Indirectly Related
Land	$549,000	$103,000
Facilities	329,000	385,000
Total	878,000	488,000

b. Functions.

(1) Supplies of water. Use of 24,000 acre-feet of active long-term storage at the Aquashicola Project would provide a net yield of 63 cubic feet per second. This flow augumentation would contribute to the satisfaction of the needs of the Allentown-Bethlehem area and the Trenton-Philadelphia area during the 50-year period under consideration.

(2) Reduction of flood damage. The short-term storage provided at the Aquashicola Project will contribute to flood stage reductions at Palmerton, just downstream from the dam, and at principal damage centers on Lehigh River below the Lehigh Gap. These damage centers include Walnutport, Northampton, Hokendauqua, Catasauqua, Allentown, Bethlehem, Freemansburg, and Easton, Pennsylvania. Combined operation of the three new major flood control projects in the Lehigh River Basin included in the water control plan will result in a stage reduction of two feet at Bethlehem, Pennsylvania for a flood similar to that experienced in 1955. This reduction is in addition to the effects of the Bear Creek Project.

(3) Recreation. The Aquashicola reservoir will provide a recreation capacity to accommodate 156,300 visitors annually, of which 100,500 are credited to directly related recreation uses. The lands to be acquired specifically for recreation development provide for public ownership of the principal part of the shoreline and space for the development of four recreation sites. Facilities would be provided for one-day outings and camping. Hunting would be permitted in appropriate season under reasonable regulation to assure public safety. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impounded water for lake fisheries as a coordinated element for the full realization of the recreation potential of the project.

172. Trexler Project.

a. Description. The Trexler Project is proposed for multiple-purpose development to provide supplies of water, flood control and recreation. The Trexler dam site is located on Jordan Creek in the Trexler Pennsylvania State Game Preserve about 1/2 mile downstream from the mouth of Mill Creek and about 8 miles northwest of Allentown, Pa. (See plate 17.) The drainage area above this site is 51 square miles. The proposed dam would be a concrete gravity type structure 800 feet long, and rise 120 feet above the creek bed. Flood waters would pass over a spillway section of the dam 200 feet long with a crest about 104 feet above the creek. Conduits through the dam with regulating gates will permit low level releases. Diversion during construction would be made over concrete monoliths left low, temporarily, for that purpose. Storage allocations for the Trexler Project, as indicated by detailed planning studies, are 800 acre-feet of inactive long-term storage to elevation 416; 24,200 acre-feet of active long-term storage for supplies of water and recreation to elevation 479; and 14,000 acre-feet of short-term storage for flood control to elevation 492. The reservoir at elevation 492 would extend about 8 miles up Jordan Creek with bays or prongs extending about 3 miles up Lyon Creek and 2 miles up Mill Creek. Fills and bridges will be required to carry U. S. Route 309 across the reservoir. Relocation of other roads and the communities of Lyon Valley and Weidasville will also be necessary. A total of 3,587 acres of land will be acquired for the complete development. In addition to the 960 acres required for construction of the project, 1,776 acres would be required for directly related recreation and 851 acres for indirectly related recreation. The total estimated project cost, excluding $1,140,000 for indirectly related recreation, is $10,100,000, which includes $1,500,000 of specific costs for directly related recreation. The directly and indirectly related recreation costs include the following:

	Estimated Specific Recreation Costs	
Item	Directly Related	Indirectly Related
Land	$1,010,000	$141.000
Facilities	486,000	1,000,000
Total	1,496,000	1,141,000

b. Functions

(1) Supplies of water. Use of 24,200 acre-feet of active long-term storage at the Trexler Project would provide a net yield of 55 cubic feet per second. This flow augmentation would contribute to the satisfaction of the needs of the Bethlehem area and the Trenton-Philadelphia area during the 50-year period under consideration.

(2) Reduction of Flood Damage. The short-term storage at the Trexler Project will contribute to flood stage reductions at the principal damage centers of Allentown, Bethlehem

and Easton, Pennsylvania. Combined operations of the three new major flood control projects included in the Lehigh River Basin in the water control plan will result in a stage reduction of two feet at Bethlehem, Pennsylvania, for a flood similar to that experienced in 1955. This reduction is in addition to the effects of the Bear Creek Project.

(3) Recreation. The Trexler reservoir will provide a recreation capacity to accommodate a total of 312,500 visitors annually of which 177,200 are credited to directly related recreation uses. The lands to be acquired specifically for recreation development would provide for public ownership of the shore area and space for the development of six recreation sites. Facilities would be provided for one-day outings as well as camping. Necessary roads, trails, sanitary and administrative facilities, and potable water also would be provided. Hunting will be permitted in appropriate season and under reasonable regulations to assure public safety. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impounded water for lake fisheries as a coordinated element for the full realization of the recreational potential of the project.

173. Maiden Creek Project.

a. Description. The Maiden Creek Project is proposed for multiple-purpose development to provide supplies of water, flood control and recreation. The Maiden Creek dam site is located on Maiden Creek about 1/3 mile upstream from the mouth of Moselem Creek and about 12 miles north of Reading, Pa. (See plate 18.) The drainage area above this site is 161 square miles. The dam, 2,600 feet long and rising 110 feet above the bed of Maiden Creek, would be of earth and rock fill construction. A conduit founded on rock along the left side of the valley would be designed to carry diversions during construction and low level reservoir releases. The spillway, 750 feet wide, would be cut through a rock ridge about 400 feet east of the dam. Storage allocations for the Maiden Creek Project, as indicated by detailed planning studies, are 2,000 acre-feet of inactive long-term storage to elevation 323; 74,000 acre-feet of active long-term storage for supplies of water and recreation to elevation 381; and 38,000 acre-feet of short-term storage for flood control to elevation 394. The reservoir would extend about 10 miles up Maiden Creek. Relocation of a railroad line, numerous roads, and the communities of Lenhartsville, Virginville and a part of Moselem would be required. There are no commercially developed mineral resources in the reservoir area. A total of 8,450 acres of land will be acquired for the complete development. In addition to the 2,850 acres required for the construction of the project, 2,255 acres would be required for directly related recreation and 3,345 for indirectly related recreation. The total estimated project cost, excluding $3,250,000 for indirectly related recreation, is $27,600,000, which includes $2,440,000 of specific costs for directly related recreation. The directly and indirectly related recreation costs include the following:

Item	Estimated Specific Recreation Costs Directly Related	Estimated Specific Recreation Costs Indirectly Related
Land	$1,280,000	$1,420,000
Facilities	1,160,000	1,830,000
Total	2,440,000	3,250,000

b. Functions.

(1) Supplies of water. Use of 74,000 acre-feet of active long-term storage at Maiden Creek Project would provide a net yield of 134 cubic feet per second. This flow augmentation would contribute to the satisfaction of the needs of the Pottstown-Reading area as well as to the Philadelphia area during the 50 year period under consideration.

(2) Reduction of flood damage. The flood control storage at Maiden Creek Project will contribute to flood stage reductions at the principal damage centers on the Schuylkill River from Reading, Pennsylvania to Philadelphia, Pennsylvania. These damage centers are Reading, Birdsboro, Pottstown, Norristown,

Conshohocken, Manayunk and Philadelphia, Pennsylvania. The floodway at these centers is occupied mostly by commercial and industrial interests which suffered about 70% of the total flood damages in these areas in August 1955. Combined operation of storage allocated to flood control at the Maiden Creek and Blue Marsh Projects in the Schuylkill River Basin would result in a flood stage reduction of about 4-1/2 feet at Reading, Pennsylvania, and of about three feet at Pottstown, Pennsylvania for a flood similar to that experienced in 1955.

(3) Recreation. The Maiden Creek reservoir would provide a recreation capacity to accommodate a total of 625,000 visitors annually of which 267,400 are credited to the directly related recreation uses. The lands to be acquired specifically for recreation development would provide for public ownership of the shore area and space for development of five recreation sites. Facilities will be provided for one-day outings and camping. Necessary access, and sanitary and administrative facilities also will be provided. Hunting will be permitted in appropriate season and under reasonable regulation to assure public safety. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impounded water for lake fisheries as a coordinated element for the full realization of the recreation potential of the project.

174. Blue Marsh Project.

a. Description. The Blue Marsh Project is proposed for multiple-purpose development to provide supplies of water, flood control and recreation. The Blue Marsh dam site is located on the Tulpehocken Creek, 1-1/2 miles upstream from the mouth of Plum Creek and about 6 miles northwest of Reading, Pa. (See plate 19.) The drainage area above this site is 175 square miles. The dam would consist of a rock and earth fill embankment 1,100 feet long and 90 feet high. A conduit on rock along the right abutment would provide for low level reservoir releases and diversion during construction. The spillway would be located about 1,000 feet south of the dam where a 900-foot wide flat crested channel cut into the shale would conduct excess water from the reservoir to Tulpehocken Creek. Final storage allocations for the Blue Marsh Project, as indicated by detailed planning studies, are 1,500 acre-feet of inactive long-term storage to elevation 249; 14,500 acre-feet of active long-term storage for supplies of water and recreation to elevation 279; and 33,000 acre-feet of short-term storage for flood control to elevation 303. The reservoir would extend upstream from the dam about 10 miles on Tulpehocken and Northkill Creeks. The reservoir would require relocation of pipelines, roads, the community of Blue Marsh and a few buildings in the Bernville area. One commercially valuable mineral deposit is located in the reservoir, a shale pit about 1 mile north of Blue Marsh. A total of about 5,296 acres of land will be acquired for the complete development. In addition to the 1,520 acres required for construction of the project, 1,093 acres will be required for directly related recreation and 2,683 acres for indirectly related recreation. The total estimated project cost, excluding $3,280,000 for indirectly related recreation, is $12,500,000, which includes $1,500,000 of specific costs for directly related recreation. The directly and indirectly related recreation costs include the following:

Item	Estimated Specific Recreation Costs: Directly Related	Estimated Specific Recreation Costs: Indirectly Related
Land	$ 664,000	$2,040,000
Facilities	832,000	1,240,000
Total	1,496,000	3,280,000

b. Functions.

(1) Supplies of water. Use of 14,500 acre-feet of active long-term storage at the Blue Marsh Project will provide a net yield of 65 cubic feet per second. This flow augmentation will contribute to the satisfaction of the needs of the Pottstown-Reading area as well as to the Philadelphia area during the 50-year period under consideration.

(2) Reduction of flood damage. The flood control storage at the Blue Marsh Project will contribute to flood stage reductions at the principal damage centers on the Schuylkill River from

Reading, Pennsylvania to Philadelphia, Pennsylvania. These damage centers are Reading, Birdsboro, Pottstown, Norristown, Conshohocken, Manayunk and Philadelphia, Pennsylvania. Combined operation of storage allocated to flood control at the Blue Marsh and Maiden Creek Projects in the Schuylkill River Basin would result in a flood stage reduction of about 4-1/2 feet at Reading, Pennsylvania, and of about three feet at Pottstown, Pennsylvania for a flood similar to that experienced in 1955.

(3) Recreation. The Blue Marsh reservoir would provide a recreation capacity to accommodate a total of 437,500 visitors annually, of which 137,000 are credited to the directly related recreation uses. The lands to be acquired specifically for recreation development would provide public ownership of the shoreline and space for the development of six recreation sites. Facilities will be provided for one-day outings as well as camping. Necessary access, sanitary and administrative facilities also will be provided. Hunting would be permitted in appropriate seasons and under reasonable regulations to assure public safety. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impounded water for lake fisheries as a coordinated element for the full realization of the recreational potential of the project.

175. Newark Project.

a. Description. The Newark Project is proposed for multiple-purpose development to provide supplies of water and recreation. The dam site is located on White Clay Creek about 1-1/2 miles north of Newark, Delaware. (See plate 20.) The drainage area above this site is 67 square miles. A concrete gravity type dam 1,200 feet long, including a spillway section 400 feet long, is proposed for this site. The non-overflow section of the dam would be 97 feet above the creek bed and the spillway crest 81 feet above that datum. Gated sluices through the dam 7 feet above the creek bed and bypass pipes would be provided for low level reservoir releases. Stream diversion during construction would be over concrete monoliths left low, temporarily, for that purpose. Storage allocations for the Newark Project are 1,000 acre-feet of inactive long-term storage to elevation 98 and 30,000 acre-feet of active long-term storage for supplies of water and recreation to elevation 156. The reservoir would extend about six miles up White Clay Creek into Pennsylvania. Relocation of 2.7 miles of county road including a bridge across the reservoir, a stream gaging station, a pumping plant and a sewer line would be required. No railroads, communities, or commercially developed mineral deposits are located in the reservoir area. A total of 6,490 acres of land would be acquired for the complete development. In addition to the 1,090 acres required for the construction of the project, 4,000 acres would be required for directly related recreation and 1,400 acres for indirectly related recreation. The total estimated project cost, excluding $3,550,000 for indirectly related recreation, is $15,300,000, which includes specific costs for directly related recreation of $5,140,000. The directly and indirectly related recreation costs include the following:

Item	Estimated Specific Recreation Costs: Directly Related	Estimated Specific Recreation Costs: Indirectly Related
Land	$3,250,000	$1,400,000
Facilities	1,890,000	2,150,000
Total	5,140,000	3,550,000

b. Functions.

(1) Supplies of Water. Use of 30,000 acre-feet of active long-term storage at Newark Project would provide a net yield of 43 cubic feet per second. This flow augmention would contribute to partial satisfaction of the needs of the Wilmington area during the 50-year period under consideration.

(2) Recreation. The Newark Project including the recreation element defined as the Mason-Dixon Interstate Park Area would provide recreation capacity for 937,500 visitors annually, of which 554,000 are credited to directly related recreation. The lands to be acquired specifically for recreation development would provide public ownership of the shore area and space for the development of

six major recreation sites. Facilities also would be provided for one-day outings and camping. Required roads, trails, sanitary and administrative facilities and potable water are included in the plan. Hunting would be permitted in appropriate season and under reasonable regulation to assure public safety. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impounded water for lake fisheries as a coordinated element for full realization of the recreation potential of the project.

176. Christiana Project.

a. Description. The Christiana Project is a multiple-purpose development to provide supplies of water and recreation. The dam site is located on Christina River about 1-1/2 miles southwest of Christiana, Delaware, and 10 miles southwest of Wilmington, Delaware. (See plate 21.) The drainage area above the site is 41 square miles. The spillway would be a concrete lined chute through the hill which constitutes the left abutment of the dam. This spillway would have a broad crest at elevation 49, about 46 feet above the river bed. Diversion flows would be carried through a concrete conduit constructed on natural ground at the base of the left abutment. Subsequent to use of this conduit for diversion, two concrete pipes would be installed in the conduit to carry low level reservoir release. Storage allocations for the Christiana Project are 1,000 acre-feet of inactive long-term storage to elevation 23, and 36,000 acre feet of active long-term storage for supplies of water and recreation to elevation 49. The reservoir will extend about 6.7 miles up the river, about 3.8 miles up Muddy Run and inundate existing Silver Lake. No main roads cross the reservoir but the State of Delaware is planning a new highway across the reservoir at a grade that would necessitate its relocation as a feature of the development of this project. This possible cost was not included in the estimates of project costs. The raising of two bridges on U. S. Route 40, raising of one mile of the Pennsylvania Railroad single track line from Porter to Newark, Delaware, and construction of two new bridges on State Route 896 would be required. There are no communities in the reservoir area and only one commercially valuable mineral deposit is located in the reservoir area, which is a gravel pit about 1/2 mile upstream from the dam site. A total of about 8,080 acres of lands would be required for the complete development. In addition to the 3,050 acres required for construction of the project, 3,057 acres would be required for directly related recreation and 1,973 acres for indirectly related recreation. The total estimated project cost, excluding $5,420,000 for indirectly related recreation, is $18,000,000 which includes $7,560,000 of specific costs for directly related recreation. The directly and indirectly related recreation costs include the following:

Item	Estimated Specific Recreation Costs Directly Related	Indirectly Related
Land	$4,770,000	$1,820,000
Facilities	2,790,000	3,600,000
Total	7,560,000	5,420,000

b. Functions.

(1) Supplies of water. Use of 36,000 acre-feet of active long-term storage at Christiana Project would provide a net yield of 34 cubic feet per second. This flow augmentation would contribute to partial satisfaction of the needs of the Wilmington area during the 50-year period under consideration.

(2) Recreation. The Christiana Project would provide a recreation capacity to accommodate about 1,875,000 visitors annually of which 1,093,000 are credited to directly related recreation. The lands to be acquired specifically for recreation development would provide for public ownership of the shore area and provide for the development of three major recreation sites. Facilities are to be provided for one-day outings and camping. Required roads, trails, sanitary and administrative facilities, and drinking water would be provided. Hunting would be permitted in appropriate season under reasonable regulation to assure public safety. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impounded waters for lake fisheries as a coordinated element for full realization of the recreation potential of the project.

177. DESCRIPTIONS OF MAJOR CONTROL PROJECTS PROPOSED FOR TWO-STAGE DEVELOPMENT. Eight major control projects are proposed for development in two stages with the initial stage for recreation in the immediate future and the second stage for water supply and other purposes as needed after year 2010. The projects included in this category and the order of the individual project descriptions are as follows:

Paulina	Tohickon
Pequest	Newtown
Hackettstown	French Creek
New Hampton	Evansburg

178. Paulina Project.

a. Description. The Paulina Project, fully developed in two stages, would be a multiple-purpose project to provide supplies of water and recreation. The initial stage of development to satisfy existing recreation needs is economically feasible and is proposed for the immediate future. It is also proposed that, contingent upon the wishes of local interests, land be acquired, for the initial stage of development, as it becomes available. Such an arrangement will assure preservation of the potential reservoir which is considered essential to water resources development in the basin after the year 2010 when full development of the site is indicated. The project site is located on Paulins Kill about 11.25 miles above the mouth and 1.5 miles east of Blairstown, New Jersey. (See plate 22.) The drainage area upstream from the dam site is 122 square miles. Suggested storage allocations for ultimate development are 4,000 acre-feet of inactive long-term storage to elevation 403 and 51,000 acre-feet of active long-term storage for supplies of water and recreation to elevation 465. The reservoir at elevation 465 would extend 14 miles upstream and provide a reservoir area of 1,650 acres. Total lands, including the eventual reservoir area, desirable for the initial stage of development comprise 5,717 acres at an estimated cost of about 8.8 million dollars. The estimated cost of the initial stage of development is 12.2 million dollars, including 5.3 million dollars to acquire the reservoir area to assure its preservation for future use and 6.9 million dollars of specific recreation costs. Included in the latter are 3.5 million dollars for recreation lands and 3.4 million dollars for recreation facilities. The estimated cost of the complete two-stage development is 23.1 million dollars of which 10.9 million dollars is the estimated cost of the dam and appurtenant works, relocations and reservoir clearing.

b. Functions.

(1) Supplies of water. When fully developed, use of 51,000 acre-feet of active long-term storage in the Paulina Project would provide a net yield of 90 cubic feet per second. This flow augmentation would contribute to the satisfaction of the water needs after the year 2010.

(2) Recreation. The Paulina Project would provide a recreation capacity to accommodate 600,000 visitors annually during the initial stage of development and 1,000,000 visitors annually when fully developed. The topography surrounding this site is steeply rolling and irregular as the result of glacial action. The overall character of the site makes it readily adaptable for nonurban recreation uses.

179. Pequest Project.

a. Description. The Pequest Project, fully developed in two stages, would be a multiple-purpose project to provide supplies of water and recreation. The initial stage of development to satisfy existing recreation needs is economically feasible and is proposed for the immediate future. It is also proposed that, contingent upon the wishes of local interests, land be acquired for the initial stage of development as it becomes available. Such an arrangement will assure preservation of the potential reservoir which is considered essential to water resources development in the basin after the year 2010 when full development of the site is indicated. The project site is located on Pequest River about 7 miles above the mouth and 2.5 miles northeast of Oxford, New Jersey. (See plate 23.) The drainage area above the dam site is 100 square miles. Suggested storage allocations for ultimate development are 3,000 acre-feet of inactive long-term storage to elevation 455 and 38,000 acre-feet of active long-term storage for supplies of water and recreation to elevation 507. The reservoir at elevation 507 would extend about 4.5 miles upstream and provide a reservoir area of 1,260 acres. Total lands, including the eventual reservoir area, desirable for the initial stage of development comprise 4,520 acres at an estimated cost of about 3.2 million dollars. The estimated cost of the initial stage of development is 5.0 million dollars, including an estimated 2.0 million dollars to acquire the reservoir area to assure its preservation for future use and 3.0 million dollars of specific recreation costs. Included in the latter are 1.2 million dollars for recreation lands and 1.8 million dollars for recreation facilities. The estimated cost of the complete two-stage development is 16.3 million dollars, of which 11.3 million dollars is the estimated cost of the dam and appurtenant works, relocations and reservoir clearing.

b. Functions.

(1) Supplies of water. When fully developed, use of 38,000 acre-feet of active long-term storage in the Pequest Project would provide a net yield of 75 cubic feet per second. This flow augmentation would contribute to the satisfaction of the water needs after the year 2010.

(2) Recreation. The Pequest Project would provide a recreation capacity to accommodate 312,000 visitors annually during the initial stage of development and 520,000 visitors annually when fully developed. The general setting of this proposed reservoir site is excellent for nonurban recreation purposes. The southeast shores are well situated for intensive day-use purposes.

180. Hackettstown Project.

a. Description. The Hackettstown Project, fully developed in two stages, would be a multiple-purpose project to provide supplies of water and recreation. The initial development to satisfy existing recreation needs is economically feasible and is proposed for the immediate future. It is also proposed that, contingent upon the wishes of local interests, land be acquired for the initial stage of development as it becomes available. Such an arrangement will assure preservation of the potential reservoir which is considered essential to water resources development in the basin after the year 2010 when full development of the site is indicated. The project site is located on Musconetcong River about three miles upstream from Hackettstown, New Jersey. (See plate 24.) The drainage area upstream from the dam site is 70 square miles. Suggested storage allocations for ultimate development are 1,000 acre-feet of inactive long-term storage to elevation 630 and 22,000 acre-feet of active long-term storage for supplies of water and recreation to elevation 665. The reservoir at elevation 665 would extend about five miles upstream and provide a reservoir area of 1,200 acres. Total lands, including the eventual reservoir area, desirable for the initial stage of development would comprise 10,362 acres at an estimated cost of 8.6 million dollars. The estimated cost of the initial stage of development is 17.1 million dollars, including an estimated 3.5 million dollars to acquire the reservoir area to assure its preservation for future use and 13.6 million dollars of specific recreation costs. Included in the latter are 5.1 million dollars for recreation lands and 8.5 million dollars for recreation facilities. The estimated cost of the complete two-stage development is 28.0 million dollars of which 10.9 million dollars is the estimated cost of the dam and appurtenant works, relocations and reservoir clearing.

b. Functions.

(1) Supplies of water. When fully developed, use of 22,000 acre-feet of active long-term storage in the Hackettstown Project would provide a net yield of 53 cubic feet per second. This flow augmentation would contribute to the satisfaction of the water needs after the year 2010.

(2) Recreation. The Hackettstown Project would provide a recreation capacity to accommodate 1,500,000 visitors annually during the initial stage of development and 2,500,000 visitors annually when fully developed. The total recreation resources available would provide outstanding nonurban recreation opportunities. The character of the area is such that facilities for every conceivable type of nonurban recreation could be included in the development plan.

181. New Hampton Project

a. Description. The New Hampton Project, fully developed in two stages, would be a multiple-purpose project to provide supplies of water and recreation. The development to satisfy existing initial recreation needs is economically feasible and is proposed for the immediate future. It is also proposed that, contingent upon the wishes of local interests, land be acquired for the initial stage of development as it becomes available. Such an arrangement will assure preservation of the potential reservoir which is considered essential to water resources development in the basin after the year 2010 when full development of the site is indicated. The project site is located on Musconetcong River 2.5 miles south of Washington, New Jersey. (See plate 25.) The gross drainage area upstream from the dam site is 123 square miles, including 70 square miles contributing to the proposed Hackettstown project. Suggested storage allocations for ultimate development are 2,000 acre-feet of inactive long-term storage to elevation 375 and 42,000 acre-feet of active long-term storage for supplies of water and recreation to elevation 426. The reservoir at elevation 426 would extend upstream from the dam about seven miles and provide a reservoir area of 1,850 acres. Total lands, including the eventual reservoir area, desirable for the initial stage of development would comprise 5,518 acres at an estimated cost of about 11.2 million dollars. The estimated cost of the initial stage of development is 16.3 million dollars including an estimated 7.3 million dollars to acquire the reservoir area to assure its preservation for future use and 9.0 million dollars of specific recreation costs. Included in the latter are 3.9 million dollars for recreation lands and 5.1 million dollars for recreation facilities. The estimated cost of the complete two-stage development is 29.6 million dollars, of which 13.3 million dollars is the estimated cost of the dam and appurtenant works, relocations and reservoir clearing.

b. Functions.

(1) Supplies of water. When fully developed, use of 42,000 acre-feet of active long-term storage in the New Hampton Project would provide a net yield of 82 cubic feet per second. (Net yield would be increased to 95 cubic feet per second with the proposed Hackettstown and New Hampton Projects operating in series.) This flow augmentation would contribute to the satisfaction of the water needs after the year 2010.

(2) Recreation. The New Hampton Project would provide a recreation capacity to accommodate 900,000 visitors annually during the initial stage of development and 1,500,000 visitors annually when fully developed. The northwest shore of the reservoir is ideally situated for the placement of day-use facilities to accommodate large visitor loads. The southeast shore rises steeply and is well forested, thus providing an interesting backdrop for day-use areas on the opposite shore.

132. Tohickon Project

a. Description. The Tohickon Project, fully developed in two stages, would be a multiple-purpose project to provide supplies of water and recreation. The initial development to satisfy existing recreation needs is economically feasible and is proposed for the immediate future. It is also proposed that, contingent upon the wishes of local interests, land be acquired for the initial stage of development as it becomes available. Such an arrangement will assure preservation of the potential reservoir which is considered essential to water resources development in the basin after the year 2010 when full development of the site is indicated. The project site is located on Tohickon Creek about one mile southwest of Ottsville, Pennsylvania. (See plate 26.) The drainage area above the dam site is 75 square miles. Suggested storage allocations for ultimate development are 1,500 acre-feet of inactive long-term storage to elevation 335 and 30,000 acre-feet of active long-term storage for supplies of water and recreation to elevation 388. The reservoir at elevation 388 would extend about 6-1/2 miles upstream and provide a reservoir area of 1,250 acres. Total lands, including the eventual reservoir area, indicated as desirable for the initial stage of development at this project would include 7,475 acres at an estimated cost of 7.9 million dollars. The estimated cost of the initial stage of development is 12.2 million dollars including an estimated one million dollars to acquire the reservoir area to assure its preservation for future use and 11.2 million dollars for specific recreation costs. Included in the latter are 6.9 million dollars for recreation lands and 4.3 million dollars for recreation facilities. The estimated cost of the complete two-stage development is 21.8 million dollars, of which 9.6 million dollars is the estimated cost of the dam and appurtenant works, relocations and reservoir clearing.

b. Functions.

(1) Supplies of water. When fully developed, use of 30,000 acre-feet of active long-term storage at Tohickon Project would provide a net yield of 49 cubic feet per second. This flow augmentation would contribute to the satisfaction of the water needs after the year 2010.

(2) Recreation. The Tohickon Project would provide a recreation capacity to accommodate about 750,000 annual visitors during the initial stage of development and 1,250,000 visitors annually when fully developed. The recreation area would be primarily developed for day-use activities.

c. Preservation of site. Late in September, 1960, the Commonwealth of Pennsylvania announced its plan to purchase land in the area of the proposed Tohickon Project for a state park. The Commonwealth's intent is to develop the area initially for recreation, and thus preserve the site for future additional development for water supply. The General Assembly of the Commonwealth has made funds in the amount of $1,000,000 available for the land acquisition program for this project.

183. Newtown Project

a. Description. The Newtown Project, fully developed in two stages, would be a multiple-purpose project to provide supplies of water and recreation. The initial development to satisfy existing recreation needs is economically feasible and is proposed for the immediate future. It is also proposed that, contingent upon the wishes of local interests, land be acquired for the initial stage of development as it becomes available. Such an arrangement will assure preservation of the potential reservoir which is considered essential to water resources development in the basin after the year 2010 when full development of the site is indicated. The project site is located on Neshaminy Creek about 19 miles upstream from its confluence with Delaware River and three miles west of Newtown, Pennsylvania. (See plate 27.) The drainage area upstream from the dam site is 150 square miles. Suggested storage allocations for ultimate development are 2,000 acre-feet of inactive long-term storage to elevation 114 and 60,000 acre-feet of active long-term storage for supplies of water and recreation to elevation 176. The reservoir at elevation 176 would extend about nine miles upstream from the dam and provide a reservoir area of 2,120 acres. Total lands, including the eventual reservoir area, desirable for the initial stage of development would comprise 7,200 acres at an estimated cost of about 21.4 million dollars. The estimated cost of the initial stage of development is 27.8 million dollars including an estimated 9.3 million dollars to acquire the reservoir area to assure its preservation for future use and 18.5 million dollars of specific recreation costs. Included in the latter are 12.1 million dollars for recreation lands and 6.4 million dollars for recreation facilities. The estimated cost of the complete two-stage development is 46.4 million dollars, of which 18.6 million dollars is the estimated cost of the dam and appurtenant works, relocations and reservoir clearing.

b. Functions.

(1) Supplies of water. When fully developed, use of 60,000 acre-feet of active long-term storage in the Newtown Project would provide a net yield of 100 cubic feet per second. This flow augmentation would contribute to the satisfaction of the water needs after the year 2010. This reservoir project is ideally located geographically for purposes of equalizing daily and weekly peaks in the municipal water demands for the Philadelphia metropolitan area and this potential further supports the need for future development of the Newtown Project for water supply purposes.

(2) Recreation. The Newtown Project would provide a recreation capacity to accommodate 1,125,000 visitors annually during the initial stage of development and 1,875,000 visitors annually when fully developed. Of considerable importance at this site is the wide expanse of open land readily adaptable for intensive nonurban recreation purposes. The terrain is ideally suited for the development of facilities to accommodate large visitor

loads. The site would be developed primarily for intensive day-outing purposes with facilities for swimming, boating, fishing, picnicking, field sports and related activities.

184. French Creek Project

a. Description. The French Creek Project, fully developed in two stages, would be a multiple-purpose project to provide supplies of water and recreation. The initial development to satisfy existing recreation needs is economically feasible and is proposed for the immediate future. It is also proposed that, contingent upon the wishes of local interests, land be acquired for the initial stage of development as it becomes available. Such an arrangement will assure preservation of the potential reservoir which is considered essential to water resources development in the basin after year 2010 when full development of the site is indicated. The project site is located about 9.5 miles above the mouth of French Creek and 8 miles west of Phoenixville, Pennsylvania. (See plate 23.) The drainage area upstream from the dam site is 47 square miles. Suggested storage allocations for ultimate development are 1,300 acre-feet of inactive long-term storage to elevation 240 and 25,700 acre-feet of active long-term storage for supplies of water and recreation to elevation 289. The reservoir at elevation 289 would extend 8 miles upstream from the dam and provide a reservoir area of 1,250 acres. Total lands, including the eventual reservoir area desirable for the initial stage of development would include 4,270 acres at an estimated cost of 6.9 million dollars. The estimated cost of the initial stage of development is 12.1 million dollars including an estimated 3 million dollars to acquire the reservoir area to assure its preservation for future use and 9.1 million dollars of specific recreation costs. Included in the latter are 3.9 million dollars for recreation lands and 5.2 million dollars for recreation facilities. The estimated cost of the two-stage development is 18.7 million dollars, of which 6.6 million dollars is the estimated cost of the dam and appurtenant works, relocations and reservoir clearing.

b. Functions.

(1) Supplies of water. When fully developed, use of 25,700 acre-feet of active long-term storage in the French Creek Project would provide a net yield of 33 cubic feet per second. This flow augmentation would contribute to the satisfaction of the water needs after the year 2010.

(2) Recreation. The French Creek Project would provide a recreation capacity to accommodate 900,000 visitors annually during the initial stage of development and 1,500,000 visitors annually when fully developed. Approximately 5,000,000 people reside within 50 miles of the site. The general setting, the shoreline topography, size of the proposed impoundment, accessibility by existing primary roads, and its proximity to large urban population combine to make this one of the most choice nonurban recreation sites in the lower Delaware River Basin. The recreation area would be primarily developed for day-use activities.

135. Evansburg Project

a. Description. The Evansburg Project, fully developed in two stages, would be a multiple-purpose project to provide supplies of water and recreation. The initial development to satisfy existing recreation needs is economically feasible and is proposed for the immediate future. It is also proposed that, contingent upon the wishes of local interests, land be acquired for the initial stage of development as it becomes available. Such an arrangement will assure preservation of the potential reservoir which is considered essential to water resources development in the basin after the year 2010 when full development of the site is indicated. The project site is located on Skippack Creek about a mile above its confluence with Perkiomen Creek and about two miles southeast of Collegeville, Pennsylvania. (See plate 29.) The drainage area above the dam site is 54 square miles. Suggested storage allocations for ultimate development are 1,500 acre-feet of inactive long-term storage to elevation 125 and 23,500 acre-feet of active long-term storage for supplies of water and recreation to elevation 166. The reservoir at elevation 166 would extend about eight miles upstream from the dam and provide a reservoir area of 1,120 acres. The total lands, including the eventual reservoir area, indicated as desirable for the initial stage of development at this project include 4,654 acres at an estimated cost of about 11.0 million dollars. The estimated cost of the initial stage of development is 16.3 million dollars which includes an estimated 4.3 million dollars to acquire the reservoir area to assure its preservation for future use and 12.0 million dollars of specific recreation costs. Included in the latter are 6.7 million dollars for recreation lands and 5.3 million dollars for recreation facilities. The estimated cost of the complete two-stage development is 23.8 million dollars, of which 7.5 million dollars is the estimated cost of the dam and appurtenant works, relocations and reservoir clearing.

b. Functions.

(1) Supplies of water. When fully developed, use of 23,500 acre-feet of active long-term storage in the Evansburg Project would provide a net yield of 36 cubic feet per second. This flow augmentation would contribute to the satisfaction of the water needs after the year 2010.

(2) Recreation. Evansburg Project would provide a recreation capacity to accommodate 936,000 visitors annually during the initial stage of development and 1,560,000 visitors annually when fully developed. The topography of the land surrounding the reservoir varies from steep near the dam site, to rolling with an exceptional amount of usable area. This area would be particularly adaptable for such activities as swimming, boating, fishing, picnicking, hiking, field sports, nature study, and group camping.

186. DESCRIPTION OF SMALL CONTROL PROJECTS. Thirty-nine small control projects are proposed as elements of the overall plan for the control and utilization of the water resources of the basin. Thirty-six can be accomplished under continuing authorizations and must be studied and reported on in detail when undertaken as features of current programs authorized either by Public Law 566 or Public Law 685. To avoid unnecessary duplication of effort, these thirty-six small control projects are not covered in survey scope detail in this report. The remaining three small control projects exceed cost limitations imposed by Public Law 685, but they are eligible for accomplishment under Public Law 566 subject to approval by the Senate Agriculture and Forestry Committee and the House Agriculture Committee. The three small control projects in this category and the order of individual project descriptions are Parkside, Swiftwater and Jim Thorpe.

187. Parkside Project.

a. Description. The Parkside Project is a single-purpose flood control project with provision for incidental recreation use of the sediment pool. The Parkside dam site is located on Cranberry Creek, one mile southeast of Parkside, Pennsylvania, and 0.5 mile upstream from the confluence of this creek with Paradise Creek. (See plate 30.) The drainage area above the dam site is 6.8 square miles. Cranberry Creek occupies a narrow wooded valley, with the Delaware, Lackawanna and Western Railroad running parallel to it high on the east side. The proposed rolled earth fill dam would have a 23-foot top width at elevation 835, 80 feet above the stream bed. Low level water releases, controlled by a slide gate, would pass through an outlet pipe having a riser up to elevation 768. The concrete-lined spillway around the left end of the dam would be 70 feet wide with an "overflow" type crest at elevation 822. The concrete lined spillway chute would be approximately 650 feet long from the crest to the point where it empties into the creek. Storage allocations for the Parkside Project are 52 acre-feet of inactive storage to elevation 768 and 2,218 acre-feet of flood control storage to elevation 822. The reservoir at the elevation of the outlet riser would form a pool of seven acres surface area. At the spillway crest elevation the reservoir would extend about one mile upstream and inundate 107 acres. No relocations are required for the development of this site. The estimated cost of this project, excluding $11,000 of specific recreation costs, is $1,020,000, including $21,000 for land easements and rights-of-way.

b. Functions.

(1) Reduction of Flood Damage. Combined operation of the flood control storage at Parkside Project and at 24 other proposed upstream auxiliary projects in the Brodhead Creek Basin will contribute to flood stage reductions in the Stroudsburg and

East Stroudsburg, Pennsylvania area. The Parkside Project specifically will contribute to reductions of stage in the major damage reach from Parkside to Stites Bridge, Pennsylvania.

(2) Recreation. The Parkside Project would provide recreation capacity to accommodate a total of 1,900 visitors annually. Land, in addition to that acquired for construction of the project, would be required to provide access to the recreation facilities. Facilities would be provided for one-day outings including facilities for picnicking, swimming, boating and fishing. The possibility of modifying the flood control project to provide for recreation development as a project purpose at the Parkside Project was investigated. For this type of project the height of the dam would be raised and additional land acquired to provide a recreation area and pool of desirable size. The estimated cost of this modification and the operation and maintenance costs for the added recreation would be charged to local interests. The studies suggest that economic feasibility of such modification is sufficiently attractive to warrant further consideration, at the time of preconstruction studies, of local recreation needs and of the desires and willingness of local interests to participate therein. A similar study was made and the same conclusions determined for the Jim Thorpe and Swiftwater Projects, which are described in subsequent paragraphs. Details of the studies made for these three small control projects are contained in appendix R.

188. Swiftwater Project.

a. Description. The Swiftwater Project is a single-purpose flood control project with provision for incidental recreational use of the sediment pool. The Swiftwater dam site is located on Swiftwater Creek 2.5 miles east of Swiftwater, Pennsylvania, and 0.8 mile upstream from the confluence with Paradise Creek. (See plate 31.) The drainage area above the dam site is 9.7 square miles. The valley at the dam site is flat-bottomed and about 400 feet wide with idle fields and brush in the flood plain. The hills on either side are partly wooded, rising over 300 feet above the valley floor. A paved secondary highway runs parallel to the valley along the north side about 25 feet above the creek. The proposed rolled earth fill dam will have a 25-foot top width at elevation 958, 88 feet above the stream bed. Low level water releases, to be controlled by a slide gate, would pass through an outlet pipe with a riser up to elevation 888. An unlined spillway chute 70 feet wide cut through rock around the right end of the dam will be approximately 850 feet long from the crest at elevation 942 to the point at which it discharges into a small existing reservoir downstream from the dam site. Storage allocations for the Swiftwater Project are 71 acre-feet of inactive storage to elevation 888, and 3,279 acre-feet of flood control storage to elevation 942. The surface area of the reservoir at elevation 888 will be nine acres. At the spillway crest elevation the reservoir will extend about one mile upstream and inundate 107 acres. Relocation of about 2,000 feet of road parallel to the reservoir site will be required. The estimated cost of this project, excluding $4,000 of specific recreation costs, is $1,080,000, including $47,000 for land easements, rights-of-way and road relocations.

b. Functions.

(1) Reduction of flood damage. Combined operation of the flood control storage at Swiftwater Project and at 24 other proposed upstream auxiliary projects in the Brodhead Creek Basin will contribute to flood stage reductions in the Stroudsburg and East Stroudsburg area. The Swiftwater Project specifically will contribute to stage reductions in the major damage reach downstream from the site from East Swiftwater to Parkside, Pennsylvania, and the Henryville, Pennsylvania area.

(2) Recreation. The Swiftwater Project would provide recreation capacity to accommodate a total of 1,300 visitors annually. Land, in addition to that acquired for construction of the project, would be required to provide access to the recreation facilities. Facilities would be provided for one-day outings including facilities for picnicking, swimming, boating, fishing and camping.

189. Jim Thorpe Project.

a. Description. The Jim Thorpe Project is a single-purpose flood control project with provision for incidental recreational use of the sediment pool. The Jim Thorpe dam site is located on Mauch Chunk Creek 2.9 miles upstream from its confluence with Lehigh River at Jim Thorpe, Pennsylvania. (See plate 32.) The drainage area above the dam site is 6.8 square miles. The creek lies in a narrow wooded valley between Pisgah Mountain on the north and Mauch Chunk Ridge on the south. A paved secondary highway runs along the north side of the valley about 100 feet above the stream at the dam site. The rolled earth fill dam will have a top width of 18 feet at elevation 988, 53 feet above the stream bed. Low level water releases, controlled by a slide gate, would pass through an outlet pipe with a riser up to elevation 952. A concrete-lined spillway around the left end of the dam would be 50 feet wide with the crest at elevation 976, and would be approximately 650 feet long from crest to the end of the lining. From that point, an earth channel about 500 feet long would carry flood flows back to the creek bed. Storage allocations for the Jim Thorpe Project are 80 acre-feet of inactive storage to elevation 952 and 1,520 acre-feet of flood control storage to elevation 976. The surface area of the reservoir at elevation 952 will be 14 acres. At the spillway crest elevation, the reservoir would extend about 1.5 miles upstream and inundate 130 acres. No relocations are required for development of this project. The estimated cost of the project, excluding $14,000 of specific recreation costs, is $469,000, including $24,000 for lands, easements and rights-of-way.

b. Functions.

(1) Reductions of Flood Damage. Operation of the flood control storage at Jim Thorpe Project contributes to flood stage reductions in the major damage reach located at the town of Jim Thorpe, Pennsylvania.

(2) Recreation. The Jim Thorpe Project would provide recreation capacity to accommodate a total of 3,800 visitors annually. Land, in addition to that acquired for construction of the project, would be required to provide access to the recreation facilities. Facilities would be provided for one-day outings including facilities for picnicking, swimming, boating, fishing and camping.

c. Evidence of local interest. The local people have demonstrated interest in this project, for multi-purpose use, by requesting planning assistance from the Soil Conservation Service.

189a. A summary cost table listing the first costs of the water control projects in the plan of development is shown in Table VII-5.

TABLE VII - 5

FIRST COSTS OF WATER CONTROL PROJECTS IN PLAN OF DEVELOPMENT

(in thousands of dollars)

(All amounts rounded; totals may not agree with sums of individual items due to rounding)

Project	Costs prior to year 2010								
	Construction for indicated purposes		Additional cost for				Total cost prior to year 2010	Cost of Construction for supplies of water subsequent to year 2010 7/	Total Cost
	Cost	Purposes 1/	Indirectly related recreation	Pumped-Storage hydroelectric development	Initial recreation development, two-stage project	Construction site preservation two-stage project			
MAJOR CONTROL PROJECTS									
Hawk Mountain	42,000	WS,R,P	-	-	-	-	42,000	-	42,000
Prompton (Modification)	4,970 2/	WS,R	387	-	-	-	5,350	-	5,350
Tocks Island	90,800	FC,WS,R,P	31,600	55,000	-	-	177,000	-	177,000
Bear Creek (Modification)	13,400 3/	WS,R	875	-	-	-	14,300	-	14,300
Beltzville	13,800	FC,WS,R	1,190	-	-	-	15,000	-	15,000
Aquashicola	19,000	FC,WS,R	488	-	-	-	19,500	-	19,500
Trexler	10,100	FC,WS,R	1,140	-	-	-	11,200	-	11,200
Maiden Creek	27,600	FC,WS,R	3,250	-	-	-	30,800	-	30,800
Blue Marsh	12,500	FC,WS,R	3,290	-	-	-	15,800	-	15,800
Newark	15,300	WS,R	3,550	-	-	-	18,800	-	18,800
Christiana	18,000	WS,R	5,420	-	-	-	23,500	-	23,500
Sub-totals	267,000	-	51,200	55,000	-	-	374,000	-	374,000
MAJOR CONTROL PROJECTS TO BE DEVELOPED IN TWO STAGES									
Paulina	-	-	-	-	6,940	5,250	12,200	10,900	23,100
Pequest	-	-	-	-	2,990	2,000	4,990	11,300	16,300
Hackettstown	-	-	-	-	13,600	3,500	17,100	10,900	28,000
New Hampton	-	-	-	-	9,070	7,250	16,300	13,300	29,600
Tohickon	-	-	-	-	11,200	1,000	12,200	9,600	21,800
Newtown	-	-	-	-	18,500	9,250	27,800	18,600	46,400
French Creek	-	-	-	-	9,050	3,000	12,100	6,600	18,700
Evansburg	-	-	-	-	12,000	4,250	16,300	7,500	23,800
Sub-totals	-	-	-	-	83,400	35,500	119,000	88,700	208,000
SMALL CONTROL PROJECTS									
Parkside	1,030 4/	FC,R	-	-	-	-	1,030	-	1,030
Swiftwater	1,080 5/	FC,R	-	-	-	-	1,080	-	1,080
Jim Thorpe	483 6/	FC,R	-	-	-	-	483	-	483
36 small control projects listed in Table VII-1	7,060	FC	-	-	-	-	7,060	-	7,060
Sub-totals	9,650	-	-	-	-	-	9,650	-	9,650
TOTAL ALL WATER CONTROL PROJECTS									
Major control projects	267,000	-	51,200	55,000	-	-	374,000	-	374,000
Major control projects to be developed in two stages	-	-	-	-	83,400	35,500	119,000	88,700	208,000
Small control projects	9,650	-	-	-	-	-	9,650	-	9,650
Total	277,000	-	51,200	55,000	83,400	35,500	502,000	88,700	591,000

Footnotes.

1/ WS - Supplies of water; R - Directly related recreation; P - Conventional hydroelectric power; FC - Flood control.
2/ Includes $620,000 for rehabilitation and $4,350,000 for modification of existing project. Excludes $3,700,000 cost of existing project.
3/ Includes $4,460,000 for rehabilitation and $8,990,000 for modification of existing project. Excludes $11,100,000 cost of existing project.
4/ Includes $11,000 optional cost for recreation facilities.
5/ Includes $4,000 optional cost for recreation facilities.
6/ Includes $14,000 optional cost for recreation facilities.
7/ These costs are included to indicate the possible magnitude of the future construction program.

CHAPTER VIII
PHYSICAL EFFECTS AND ECONOMICS OF THE PLAN

190. GENERAL NATURE OF EVALUATIONS. The extent and effectiveness of the plan of development to satisfy the needs for the products and services to be derived from the control and utilization of the basin's water resources were evaluated in terms of the physical effects and the economics of the improvements. The results of these evaluations are summarized in the paragraphs below.

191. PHYSICAL EFFECTS AND SERVICES OF MAJOR CONTROL PROJECTS. The effect of the major control projects when operated as a coordinated system would be to impound excess surface runoff for flood control, for in-place use, and for delayed release and use downstream during periods of low flows. The basinwide effects of the proposed system of impoundments are shown in table VIII-1 by subbasins in terms of peak discharges for the floods of May 1942, August 1955 and the hypothetical basin project flood. The reductions in flood peaks and stages were obtained from hypothetical operations to reduce flood flows as nearly as possible to the safe discharge capacities of the stream channels. The reductions shown under the proposed plan include the effects of flood control storage at the Tocks Island, Beltzville, Aquashicola, Trexler, Blue Marsh and Maiden Creek Projects. The flood reductions shown for existing projects or for projects under construction include the effects of Bear Creek, Edgar Jadwin and Prompton reservoirs.

192. The effects of operation of the system to meet the projected 1988 and 2010 needs for supplies of water at key demand points in the basin are shown in tables VIII-2 and VIII-3, respectively, for a three-year drought period corresponding to that of the 1930's. In these tables the reference flows include flow modifications for all existing projects and the effects of a projected operation of the three reservoirs of the New York City Board of Water Supply (Pepacton, Neversink and Cannonsville) at the target demand years. The progressive availability of water to satisfy all the projected requirements at Bethlehem, Trenton, Pottstown and Philadelphia, is shown in table VIII-4. The system also creates sufficient excess in the combined flows of the Schuylkill and Delaware Rivers to permit supplementary diversions to the Wilmington area of such amount as to completely satisfy the water needs of that area after the flow augmentations produced by the Newark and Christiana Projects have been fully realized.

193. The four projects in the Lehigh River Basin, Bear Creek, Beltzville, Aquashicola and Trexler, will provide flows of not less than 710 cubic feet per second at Bethlehem, Pennsylvania. Hawk Mountain, Prompton and Tocks Island, in coordinated operation with the Lehigh projects, will provide flows not less than 4,720 cubic

TABLE VIII-1

FLOOD CONTROL EFFECTS OF THE RESERVOIR SYSTEM

	Actual		Regulated by Existing Reservoirs and Projects under Construction		Regulated by Water Control Plan	
	Discharge (c.f.s.)	Stage 1/ (ft.)	Discharge (c.f.s.)	Stage 1/ (ft.)	Discharge (c.f.s.)	Stage 1/ (ft.)
Flood of May 1942						
Delaware R. at Belvidere, N. J.	133,700	21.2	119,000	20.0	43,000	12.1
Lehigh R. at Bethlehem, Pa.	92,000	23.5	72,100	19.9	63,500	18.3
Delaware R. at Riegelsville, N. J.	164,000	26.7	144,000	24.9	85,000	18.4
Delaware R. at Trenton, N. J.	161,200	13.4	140,000	12.3	80,000	8.6
Schuylkill R. at Reading, Pa.	43,000	20.6	43,000	20.6	27,400	15.9
Schuylkill R. at Pottstown, Pa.	50,800	20.2	50,800	20.2	40,500	17.5
Schuylkill R. at Philadelphia, Pa.	61,900	12.4	61,900	12.4	48,800	11.4
Flood of August 1955						
Delaware R. at Belvidere, N. J.	275,000	30.31	273,000	30.2	121,000	20.2
Lehigh R. at Bethlehem, Pa.	91,300	23.38	83,000	21.9	72,000	19.9
Delaware R. at Riegelsville, N. J.	340,000	38.85	304,000	36.7	164,000	26.6
Delaware R. at Trenton, N. J.	329,000	20.83	295,500	19.5	162,000	13.5
Schuylkill R. at Reading, Pa.	33,300	18.06	33,300	18.06	21,200	13.7
Schuylkill R. at Pottstown, Pa.	42,300	17.98	42,300	17.98	31,300	15.0
Schuylkill R. at Philadelphia, Pa.	90,100	14.32	90,100	14.32	88,000	14.2
Basin Project Flood	Natural					
Delaware R. at Belvidere, N. J.	321,000	33.0	283,500	30.9	127,500	20.7
Lehigh R. at Bethlehem, Pa.	133,900	30.1	104,200	25.4	81,700	21.6
Delaware R. at Riegelsville, N. J.	423,800	43.1	368,000	40.1	166,000	26.8
Delaware R. at Trenton, N. J.	417,200	23.9	358,000	21.9	167,000	13.7
Schuylkill R. at Reading, Pa.	88,500	28.0	88,500	28.0	52,600	22.8
Schuylkill R. at Pottstown, Pa.	109,000	32.0	109,000	32.0	74,500	25.5
Schuylkill R. at Philadelphia, Pa.	191,000	19.7	191,000	19.7	180,000	19.1

1/ Based on 1955 stage-discharge rating information.

TABLE VIII-2

EFFECTS OF PLAN OF IMPROVEMENT ON LOW FLOWS DURING DROUGHT OF 1930-1932
WITH PROJECTED WATER DEMANDS OF YEAR 1988
(in cubic feet per second)

	Lehigh River at Bethlehem		Delaware River at Trenton		Schuylkill River at Pottstown		Schuylkill River at Philadelphia		Del. R. at Trenton + Sch. R. at Phila.	
	Reference Flow	Modified Flow	Reference Flow	Modified Flow	Reference Flow	Modified Flow	Reference Flow	Modified Flow	Reference Flow	Modified Flow
1930	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
January	2,270	2,270	10,490	10,490	1,730	1,730	2,650	2,650	13,140	13,140
February	2,060	2,060	10,420	10,420	2,160	2,160	3,870	3,870	14,290	14,290
March	3,110	3,110	16,270	16,270	2,520	2,520	3,740	3,740	20,010	20,010
April	3,290	3,290	13,070	13,070	2,330	2,330	3,180	3,180	16,250	16,250
May	2,280	2,280	6,640	6,640	1,300	1,300	1,870	1,870	8,510	8,510
June	2,010	2,010	7,680	7,680	950	950	1,300	1,300	8,980	8,980
July	1,120	1,160	3,950	3,990	460	510	650	700	4,600	4,690
August	560	860	2,700	3,650	310	550	410	640	3,110	4,290
September	520	790	2,690	3,650	350	570	440	650	3.130	4,300
October	400	660	2,540	3,650	260	490	300	530	2,840	4,180
November	420	590	2,910	3,650	310	470	410	560	3,320	4,210
December	470	580	3,040	3.650	420	520	590	690	3,630	4,340
1931										
January	690	670	4,160	3,960	690	630	1,060	1,000	5,220	4,960
February	1,080	1,030	4,810	4,430	950	830	1,550	1,420	6,360	5,850
March	2,100	1,720	10,710	7,560	1,360	970	2,010	1,620	12,720	9,180
April	2,770	2,250	16,160	15,640	1,510	1,100	2,180	1,770	18,340	17,410
May	2,760	2,600	13,040	12,880	1,800	1,780	2,430	2,420	15,470	15,300
June	1,410	1,410	8,100	8,100	1,100	1,100	1,790	1,790	9,890	9,890
July	1,490	1,490	8,950	8,950	1,370	1,370	2,790	2,790	11,740	11,740
August	840	870	3,700	3,740	740	740	1,290	1,290	4,990	5,030
September	700	880	3,130	3,650	550	690	880	1,020	4,010	4,570
October	460	740	2,550	3,650	400	640	600	840	3,150	4,490
November	410	670	2,460	3,650	310	560	440	700	2,900	4,350
December	620	750	3,650	3,650	530	650	740	860	4,390	4,510
1932										
January	1,630	1,380	9,840	7,630	1,900	1,620	3,030	2,750	12,870	10,380
February	1,710	1,480	10,640	10,420	1,210	960	1,700	1,460	12,340	11,880
March	2,110	1,820	8,540	8,240	2,290	2,070	3,620	3,400	12,160	11,640
April	3,440	3,310	18,780	18,650	2,500	2,500	3,790	3,790	22,570	22,440
May	1,920	1,920	8,540	8,540	1,880	1,880	2,560	2,560	11,100	11,100
June	1,420	1,420	6,040	6,040	1,060	1,060	1,360	1,360	7,400	7,400
July	910	1,030	3,760	3,890	560	640	730	810	4,490	4,700
August	550	810	2,680	3,650	440	650	580	790	3,260	4,440
September	370	660	2,440	3,650	260	520	350	620	2,790	4,270
October	1,420	1,190	7,710	5,860	1,260	990	1,750	1,480	9,460	7,340
November	4,950	4,500	22,640	22,190	3,760	3,470	6,420	6,130	29,060	28,320
December	1,710	1,710	7,880	7,880	1,530	1,530	2,380	2,380	10,260	10,260

Reference flows in columns (1), (5), and (7) are observed mean monthly flows.

Columns (3) and (9) are modified for the effects of a projected operation of Pepacton, Neversink and Cannonsville with diversion of 800 mgd to NYC and maintenance of 1750 cfs at Montague, NJ, in accordance with provisions of the Supreme Court Decree of 1954.

Columns (2), (4), (6), (8) and (10) are modified flows resulting from operation of the proposed system of impoundments.

TABLE VIII-3

EFFECTS OF PLAN OF IMPROVEMENT ON LOW FLOWS DURING DROUGHT OF 1930-1932
WITH PROJECTED WATER DEMANDS OF YEAR 2010

(in cubic feet per second)

	Lehigh River at Bethlehem		Delaware River at Trenton		Schuylkill River at Pottstown		Schuylkill River at Philadelphia		Del. R. at Trenton + Sch. R. at Phila.	
	Reference Flow	Modified Flow	Reference Flow	Modified Flow	Reference Flow	Modified Flow	Reference Flow	Modified Flow	Reference Flow	Modified Flow
1930	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
January	2,270	2,270	10,490	10,490	1,730	1,730	2,650	2,650	13,140	13,140
February	2,060	2,060	10,420	10,420	2,160	2,160	3,870	3,870	14,290	14,290
March	3,110	3,110	16,270	16,270	2,520	2,520	3,740	3,740	20,010	20,010
April	3,290	3,290	13,070	13,070	2,330	2,330	3,180	3,180	16,250	16,250
May	2,280	2,280	6,640	6,640	1,300	1,300	1,870	1,870	8,510	8,510
June	2,010	2,010	7,680	7,680	950	950	1,300	1,300	8,980	8,980
July	1,120	1,290	3,950	5,040	460	630	650	820	4,600	5,860
August	560	1,190	2,700	5,170	310	600	410	690	3,110	5,860
September	520	1,090	2,690	5,150	350	620	440	710	3,130	5,860
October	400	950	2,540	5,280	260	550	300	580	2,840	5,860
November	420	810	2,910	5,230	310	540	410	630	3.320	5,860
December	470	740	3,040	5,120	420	590	590	760	3,630	5,880
1931										
January	690	740	4,160	4,760	690	730	1,060	1,100	5,220	5,860
February	1,080	1,030	4,810	4,720	950	910	1,550	1,510	6,360	6,230
March	2,100	1,260	10,710	4,720	1,360	1,000	2,010	1,650	12,720	6,370
April	2,770	1,450	16,160	8,900	1,510	1,100	2,180	1,770	18,340	10,670
May	2,760	2,350	13,040	12,630	1,800	1,200	2,430	1,830	15,470	14,460
June	1,410	1,410	8,100	8,100	1,100	1,040	1,790	1,730	9,890	9,830
July	1,490	1,490	8,950	8.950	1,370	1,370	2,790	2,790	11,740	11,740
August	840	1,060	3.700	4,720	740	860	1,290	1,410	4.990	6.130
September	700	1,130	3,130	4,760	550	780	880	1,100	4,010	5,860
October	460	1,040	2,550	4,980	400	680	600	880	3,150	5,860
November	410	940	2,460	5,130	310	600	440	730	2,900	5,860
December	620	910	3.650	4,940	530	710	740	920	4,390	5,860
1932										
January	1.630	980	9,840	4,720	1,900	1,620	3,030	2,750	12,870	7,470
February	1,710	1,140	10,640	7,560	1,210	960	1,700	1,460	12,340	9,020
March	2,110	1,370	8,540	7,790	2,290	1,830	3,620	3,160	12,160	10,950
April	3,440	3,340	18,780	18,680	2,500	2,390	3.790	3,680	22,570	22.360
May	1,920	1,920	8,540	8,540	1,880	1,880	2,560	2,560	11,100	11,100
June	1,420	1,420	6,040	6,040	1,060	1,090	1,360	1,390	7,400	7,430
July	910	1,210	3,760	4,960	560	730	730	900	4,490	5,860
August	550	1,100	2,680	5,010	440	710	580	850	3,260	5,860
September	370	980	2,440	5,200	260	560	350	660	2,790	5,860
October	1,420	1,000	7,710	4,720	1,260	1,060	1,750	1,550	9,460	6,270
November	4,950	3,910	22,640	19,320	3.760	3.180	6,420	5,840	29,060	25,160
December	1,710	1,710	7,880	7,880	1,530	1,530	2,380	2,380	10,260	10,260

Reference flows in columns (1), (5), and (7) are observed mean monthly flows.

Columns (3) and (9) are modified for the effects of a projected operation of Pepacton, Neversink and Cannonsville with diversion of 800 mgd to NYC and maintenance of 1750 cfs at Montague, NJ, in accordance with provisions of the Supreme Court Decree of 1954.

Columns (2), (4), (6), (8) and (10) are modified flows resulting from operation of the proposed system of impoundments.

TABLE VIII-4

PROGRESSIVE AVAILABILITY OF WATER AT KEY PLACES AT TIMES OF COMPLETION OF ELEMENTS OF PROPOSED PLAN
(all quantities in c. f. s.)

Completion Date	1960	1965	1969	1972	1974	1975	1981	1982	1989	2001
Project and Net Yield 1/	NONE	Beltz-ville 80	Blue Marsh 65	Trex-ler 55	Promp-ton 57	Tocks Island 968 2/	Aquashi-cola 63	Maiden Creek 134	Bear Creek 196	Hawk Mtn. 465 3/
Lehigh R. at Bethlehem 4/	320	400	400	455	455	455	518	518	710	710
Delaware R. at Trenton 5/	2,840	2,920	2,920	2,975	3,032	4,000	4,063	4,063	4,259	4,720
Schuylkill R. at Pottstown 6/	294	294	359	359	359	359	359	490	490	490
Schuylkill R. at Philadelphia	350	350	415	415	415	415	415	550	550	550
Delaware R. at Trenton and Schuylkill R. at Philadelphia 7/	3,190	3,270	3,390	3,390	3,447	4,415	4,478	4,613	4,809	5,270

1/ Net yield is the effective augmentation of flow ascribable to the project at downstream points.
2/ Adjusted for prior existence of Prompton Project.
3/ Adjusted for prior existence of Prompton and Tocks Island Projects.
4/ Lehigh River flows at Bethlehem augmented by Beltzville, Trexler, Aquashicola and Bear Creek Projects.
5/ Delaware River flows at Trenton augmented by Prompton, Tocks Island, Hawk Mountain and Lehigh R. Projects.
6/ Schuylkill River flows at Pottstown and Philadelphia augmented by Blue Marsh and Maiden Creek Projects.
7/ Combined flows of Delaware River at Trenton and Schuylkill River at Philadelphia. Does not include contribution from Delaware River tributaries between Trenton and Philadelphia.

feet per second at Trenton, New Jersey. The two Schuylkill Basin projects, Blue Marsh and Maiden Creek, will provide flows of not less than 490 cubic feet per second and 550 cubic feet per second at Pottstown and Philadelphia, Pennsylvania, respectively. The two projects in the Christina River Basin, Newark and Christiana, in conjunction with diversion from a fresh water reach of the Delaware River, in the vicinity of Philadelphia, will provide flows of not less than 680 cubic feet per second at Wilmington, Delaware.

194. Facilities will be provided in the Hawk Mountain and Tocks Island Projects for the generation of electrical energy. The indicated installed and dependable capacities and the average annual energy to be produced at each of these projects are shown in table VIII-5.

TABLE VIII-5
POWER PRODUCTION AT MAJOR CONTROL PROJECTS

Project	KW Capacity		Average Annual Energy in Million KW-Hrs.
	Installed	Dependable	
Hawk Mountain	21,000	11,000	93.8
Tocks Island			
Conventional	46,000	20,000	281.5
Pumped-Storage	366,000	342,000	732.0
Total	433,000	373,000	1,107.3

195. The recreation facilities proposed for development by the year 2010 to be provided at the 19 major control projects, including the indirectly related recreation facilities, will provide recreation opportunities amounting to an average of about 19,200,000 visitor-days annually. Of this total, about 12,300,000 visitor-days annually are credited to directly related and initial stage recreation developments and the remaining 6,900,000 visitor-days would accrue to the indirectly related reserves. A total of 29,400 acres of water surface and 132,900 acres of land area would be made available for recreation use in and around these projects. Table VIII-6 shows the water and land surface areas, and the visitor-day capacity for each of the major control projects. In view of the multi-purpose use of the proposed major water control projects, it was recognized that releases from the reservoirs for supplies of water and production of power might have an adverse effect upon recreational use of the reservoirs. In order to determine whether drawdown would be significant, drawdown-frequency relationships for the primary recreation season, June through August, and for the period May through September, were developed for seven representative major reservoirs, in different parts of the basin, from among those included in the proposed plan. Details and results of the analysis made to develop these relationships are contained in appendix M. From the recreation viewpoint, a drawdown of 15 feet or more is con-

TABLE VIII-6

RECREATION OPPORTUNITIES AT MAJOR CONTROL PROJECTS

Project	Joint Use Lands and Water Areas (in acres)		Specific Recreation Lands (in acres)		Average Annual Gross Visitation (in 1,000 Visitor-Days)		
	Water Surface 1/	Lands 2/	Directly Related	Indirectly Related	Directly Related	Indirectly Related	Total
Hawk Mountain	5,400	400	2,000	-	187.0	-	187.0
Prompton	720	10	925	400	81.9	74.4	156.3
Tocks Island	12,100	2,700	9,500	38,070	2,470.0	4,280.0	6,750.0
Bear Creek	1,280	670	1,300	700	101.2	148.8	250.0
Beltzville	870	160	723	660	110.0	390.0	500.0
Aquashicola	840	60	770	480	100.5	55.8	156.3
Trexler	880	80	1,776	851	177.2	135.3	312.5
Maiden Creek	2,500	350	2,255	3,345	267.4	357.6	625.0
Blue Marsh	870	650	1,093	2,683	137.0	300.5	437.5
Newark	1,060	30	4,000	1,400	554.0	383.5	937.5
Christiana	2,900	150	3,057	1,973	1,093.1	781.9	1,875.0
Total	29,420	5,260	27,399	50,562	5,279.3	6,907.8	12,187.1
			Total Lands		Initial Stage	Second Stage 4/	Complete Development
Paulina	3/	1,940	3,777		600.0	400.0	1,000.0
Pequest	3/	1,520	3,000		312.0	208.0	520.0
Hackettstown	3/	1,370	8,992		1,500.0	1,000.0	2,500.0
New Hampton	3/	2,070	3,448		900.0	600.0	1,500.0
Tohickon	3/	1,375	6,100		750.0	500.0	1,250.0
Newtown	3/	2,400	4,800		1,125.0	750.0	1,875.0
French Creek	3/	1,750	2,520		900.0	600.0	1,500.0
Evansburg	3/	1,290	3,364		936.0	624.0	1,560.0
Total		13,715	36,001		7,023.0	4,682.0	11,705.0

1/ Area at top of long-term impoundment.
2/ Includes area subject to short-term impoundments, if any.
3/ No significant impoundment proposed in initial stage of development.
4/ To be developed after the year 2010.

sidered undesirable. The analysis indicated that a drawdown of this magnitude might occur during two to eight percent of the months in the period of June through August over a long period of time. Drawdowns of 20 feet or more would occur much less frequently and the occurrence of maximum drawdowns would be rare. The average frequency of occurrence of a 15-foot drawdown for the seven reservoirs studied is about five percent of the months, or about one month every seven years. During low reservoir stages some inconvenience may be experienced with regard to the recreational use of the reservoir, but boating and fishing could be continued and full use could be made of other recreation facilities provided at the projects. It is considered, therefore, that the infrequent occurrence of a 15-foot drawdown would not reduce appreciably the recreational use of the reservoirs nor reduce significantly the benefits assigned to the recreation purpose of the projects.

196. PHYSICAL EFFECTS AND SERVICES OF SMALL CONTROL PROJECTS. Each of the proposed small control projects would be effective, primarily, in the reduction of flood damages in the local reaches downstream from the dam site. In addition, specific lands and facilities for incidental recreation are proposed for the Parkside, Swiftwater and Jim Thorpe Projects. The possibility of incorporating recreation as a project purpose at these three projects appears attractive and should be considered further as indicated in paragraph 187 above. The remaining thirty-six projects in this category also have potentials for providing local recreation opportunities. These potentials would need to be defined and evaluated in accordance with local needs and desires at the time the individual projects are studied for development under existing programs and continuing authorities. All thirty-nine of the proposed small control projects have potentials for the development of water supplies to meet local demands as they arise. As in the case of recreation potentials, the water supply potentials at these projects would be entirely at local expense and should be defined and evaluated in accordance with local needs and desires at the time preconstruction studies are made for the individual projects. The need for multiple-purpose development of the small control projects to include local water supplies was not indicated at the time of this investigation. The overall definition and evaluation of single-purpose parks and water supply impoundments to meet local recreation and water needs was not undertaken as a feature of this investigation.

197. Because of the small sizes of the drainage areas controlled, the proposed small control projects were considered to be effective in controlling flood flows in reaches of the streams from the dam site to a point downstream where the drainage area is approximately twenty times the area controlled by the individual project. The reductions of flood stages and discharges credited to the small control projects were generalized on the basis of typical hydrographs with peak discharges of selected frequencies of occurrence at the point of reference

in the basin. These hypothetical reductions served as the basis for estimates of flood control benefits. The area of effectiveness and the flood control benefits assignable to the Parkside, Swiftwater and Jim Thorpe Projects are shown in table VIII-7. Data on the effects of the remaining thirty-six small control projects are shown in that table for groups of projects with the same general areas of effectiveness.

TABLE VIII-7
FLOOD CONTROL EFFECTS OF SMALL CONTROL PROJECTS

Project	Effective Area of Flood Damage Reduction	Annual Value of Flood Damage Reduction
Parkside	Parkside to Stites Bridge, Pa.	$ 41,800
Swiftwater	E. Swiftwater to Parkside & Henryville, Pa.	70,600
Jim Thorpe	Jim Thorpe, Pa.	17,800
2 Projects	Walton, N. Y.	35,500
1 Project	Callicoon Ctr., N.Br. & Hortonville, N.Y.	20,800
23 Projects	Canadensis to Stroudsburg, Pa.	298,000
3 Projects	Bath Jctn., Stockerton & Martins Cr., Pa.	50,000
2 Projects	Neshaminy, Hulmeville & Chalfont, Pa.	22,900
5 Projects	Norristown, NE. Area & Fairmount Park in Philadelphia and Ft. Washington, Pa.	29,600

198. Water surface areas and estimated visitor-day capacities for the three small control projects at which recreation facilities have been included are shown in table VIII-8.

TABLE VIII-8
RECREATION OPPORTUNITIES AT SMALL CONTROL PROJECTS

Project	Water Surface Area in Acres 1/	Average Annual Visitor-Days
Parkside	7	1,900
Swiftwater	9	1,300
Jim Thorpe	14	3,800

1/ Area at top of outlet riser

199. SUCCESSIVE PLANNING EVALUATIONS. The broad objective followed in the formulation of the plan of improvement was to maximize net economic gains and human satisfactions from the use of physical and economic resources of the basin. The first steps to attain this objective, as reported in chapter VI, involved an assessment of the needs for the products and services to be gained by water resources development and an inventory of the potential measures that could serve to fill these needs. Then followed a

series of evaluations to establish the plan of development that would accomplish the task of supplying the needed products and services with optimum effectiveness and economy.

200. These evaluations, as described in detail in appendix Q, involved, first, an index of worth or merit for each of the major projects under consideration. These indexes were based on preliminary appraisals of the worth and costs of the individual projects acting as independent units. The indexes of merit were then used in defining a number of alternative plans of development designed essentially to satisfy the needs of the basin with regard to the type and quantity of needed products and services and the timeliness of their satisfaction. A complete, yet preliminary, appraisal of the economic worth and cost was made for each alternate plan under consideration. These appraisals served as the basis for selecting from the several plans, a single basic plan to produce, in a balanced manner, the needed goods and services with the least investment of water resources and funds. With due consideration as to the nature of the monetary appraisals used in this planning step and the character of enabling assumptions adopted for the appraisals, the selection of the basic plan was based, essentially, on optimized net returns for each plan, or segment thereof, under consideration.

201. The plan thus selected was tailored to adhere to refined estimates of needs and to avoid untimely production of certain goods and services. Then, each element proposed for multiple-purpose development, requiring both long-term and short-term storage, was evaluated over a range of sizes and storage allocations to adjust the project dimensions and storage allocations for maximized net benefits at individual sites. Finally, the elements of the plan were arranged chronologically to assure necessary balance and timeliness of products and services. The major control elements of the plan of development thus defined were described in the previous chapter. The small control projects, also described in chapter VII, were added to the plan to satisfy the needs for flood control in the intermediate upstream areas of the basin since these upstream problems were susceptible to economically feasible solution only by means of control projects of this type.

202. <u>BENEFITS AND COSTS</u>. The soundness of the project formulation and economic justification was tested further by appraisals to assure that; (a) the elements of the plan not preclude by their development, any more effective or economical means of accomplishing the same purposes; (b) each separable element or project purpose provides benefits at least equal to its cost; and (c) the project benefits exceed project costs. The project costs and benefits used in these appraisals were estimated on the basis of generally accepted evaluation criteria with adjustments to reflect the 1959 price level.

The following paragraphs describe and summarize by individual projects the economic costs and benefits, allocations of costs to project purposes, and apportionments of costs between Federal and non-Federal interests.

203. Costs. First costs comprise all initial expenditures associated with construction of the project such as lands and damages, relocations, reservoir clearing, dam and appurtenant works, dikes, access roads, buildings and utilities, engineering and design, supervision and administration. The first costs for all projects in the proposed system are shown in column 1, table VIII-9. Table VIII-9 also shows the annual economic charges, which include interest and amortization (at a uniform low-risk interest rate of 2½% for 50-year period), operation and maintenance charges, cost of major replacements, an allowance to reflect the economic costs of land, and an allowance for taxes foregone.

204. Benefits. The total annual benefits for each project shown in column 9, table VIII-9, represent the sum of all monetary benefits assignable to the operation of the project. These benefits were measured at their point of production. Where benefits are expected to accrue due to future flood plain development and future use of supplies of water, the benefits were discounted on the basis of projected trends in flood plain development and projected needs for supplies of water. In the evaluation of such benefits, they were discounted at the long-range risk-free interest rate of 2½%. The estimates of annual benefits are shown in table VIII-9 and described below:

a. Reduction of flood damages. The average annual benefit for flood damage reduction assignable to each project was obtained from average annual stage-damage frequency relations as modified by each project in the time sequence indicated in table VII-1 with allowance for projected trends of flood plain development over the 50-year life of the project. If a vigorous and effective flood plain zoning program were pursued, and it were effective in eliminating 50% of this projected flood plain development, an analysis showed that, for all projects in the plan of development the justifications would not be critically affected by this reduction in projected benefits. Further benefits were assigned to flood damage reduction on the basis of the expected increased market value of lands attributable to higher utilization of property made possible thereby. To assure sound incremental justification for the inclusion of flood control features under any possible sequence of construction of the projects, the flood control benefits for each project were checked on a last-added-project basis.

b. Supplies of water. Benefits were assessed for supplies of water on the basis of the cost of providing the same quantity and quality of water by the cheapest alternative means. The estimated costs of production by alternative means were defined by assumed non-Federal financing and interest rates for existing private and publicly-owned projects throughout the basin. These estimated costs were reduced to average costs per unit of augmented flow from existing projects at various locations in the basin. The benefits cred-

TABLE VIII-9

FIRST COSTS, ANNUAL CHARGES, AND ANNUAL BENEFITS FOR WATER CONTROL PROJECTS IN PLAN OF DEVELOPMENT
(in thousands of dollars)

(All amounts rounded; totals may not agree with sum of individual items due to rounding)

Project	Construction Expenditures (First Cost)	Annual Charges 1/	ANNUAL BENEFITS: Reduction of Flood Damages	Recreation: Directly Related	Recreation: Indirectly Related	Supplies of Water	Hydroelectric Power: Conventional	Hydroelectric Power: Pumped-Storage	Total
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
MAJOR CONTROL PROJECTS									
Hawk Mountain	42,000	2,060	-	291	-	2,180	755	-	3,230
Prompton (Modification)	4,970	289	2/	130	-	307	-	-	437
3/	387	32	-	-	118	-	-	-	118
	5,350	321	-	130	118	307	-	-	555
Tocks Island	146,000	13,700	1,460	3,660	-	3,800	1,820	11,000	21,800
3/	31,600	2,500	-	-	6,340	-	-	-	6,340
	177,000	16,200	1,460	3,660	6,340	3,800	1,820	11,000	28,100
Bear Creek (Modification) 3/	13,400	628	4/	161	-	1,300	-	-	1,460
	875	69	-	-	236	-	-	-	236
	14,300	697	-	161	236	1,300	-	-	1,700
Beltzville	13,800	628	286	174	-	669	-	-	1,130
3/	1,190	72	-	-	618	-	-	-	618
	15,000	700	286	174	618	669	-	-	1,750
Aquashicola	19,000	800	293	159	-	485	-	-	937
3/	488	26	-	-	88	-	-	-	88
	19,500	826	293	159	88	485	-	-	1,030
Trexler	10,100	512	114	281	-	464	-	-	859
3/	1,140	74	-	-	215	-	-	-	215
	11,200	586	114	281	215	464	-	-	1,070
Maiden Creek	27,600	1,220	244	424	-	833	-	-	1,500
3/	3,250	224	-	-	568	-	-	-	568
	30,800	1,450	244	424	568	833	-	-	2,070
Blue Marsh	12,500	611	302	217	-	531	-	-	1,050
3/	3,290	218	-	-	477	-	-	-	477
	15,800	829	302	217	477	531	-	-	1,530
Newark	15,300	856	-	876	-	794	-	-	1,670
3/	3,550	254	-	-	606	-	-	-	606
	18,800	1,110	-	876	606	794	-	-	2,280
Christiana	18,000	1,100	-	1,730	-	639	-	-	2,370
3/	5,420	424	-	-	1,240	-	-	-	1,240
	23,500	1,530	-	1,730	1,240	639	-	-	3,610
Sub-Totals	322,000	22,400	2,700	8,110	-	12,000	2,580	11,000	36,400
3/	51,200	3,900	-	-	10,500	-	-	-	10,500
	374,000	26,300	2,700	8,110	10,500	12,000	2,580	11,000	46,900
MAJOR CONTROL PROJECTS TO BE DEVELOPED IN TWO STAGES									
Paulina 5/	6,940	533	-	960	-	-	-	-	960
6/	5,250	185	-	-	-	7/	-	-	-
8/	10,900	9/	-	640 10/	-	11/	-	-	640
	23,100	718	-	1,600	-	-	-	-	1,600
Pequest 5/	2,990	260	-	499	-	-	-	-	499
6/	2,000	70	-	-	-	7/	-	-	-
8/	11,300	9/	-	333 10/	-	11/	-	-	333
	16,300	330	-	832	-	-	-	-	832
Hackettstown 5/	13,600	1,230	-	2,400	-	-	-	-	2,400
6/	3,500	123	-	-	-	7/	-	-	-
8/	10,900	9/	-	1,600 10/	-	11/	-	-	1,600
	28,000	1,350	-	4,000	-	-	-	-	4,000
New Hampton 5/	9,070	724	-	1,440	-	-	-	-	1,440
6/	7,250	256	-	-	-	7/	-	-	-
8/	13,300	9/	-	960 10/	-	11/	-	-	960
	29,600	980	-	2,400	-	-	-	-	2,400
Tohickon 5/	11,200	811	-	1,200	-	-	-	-	1,200
6/	1,000	35	-	-	-	7/	-	-	-
8/	9,600	9/	-	800 10/	-	11/	-	-	800
	21,800	846	-	2,000	-	-	-	-	2,000
Newtown 5/	18,500	1,530	-	1,800	-	-	-	-	1,800
6/	9,250	326	-	-	-	7/	-	-	-
8/	18,600	9/	-	1,200 10/	-	11/	-	-	1,200
	46,400	1,860	-	3,000	-	-	-	-	3,000
French Creek 5/	9,050	729	-	1,440	-	-	-	-	1,440
6/	3,000	106	-	-	-	7/	-	-	-
8/	6,600	9/	-	960 10/	-	11/	-	-	960
	18,600	835	-	2,400	-	-	-	-	2,400
Evansburg 5/	12,000	952	-	1,500	-	-	-	-	1,500
6/	4,250	150	-	-	-	7/	-	-	-
8/	7,500	9/	-	1,000 10/	-	11/	-	-	1,000
	23,800	1,100	-	2,500	-	-	-	-	2,500
Sub-Totals 5/	83,400	6,770	-	11,200	-	-	-	-	11,200
6/	35,500	1,250	-	-	-	7/	-	-	-
8/	88,700	9/	-	7,490 10/	-	11/	-	-	7,490
	208,000	8,020	-	18,700	-	-	-	-	18,700

TABLE VIII-9 Continued

Project		Construction Expenditures (First Cost)	Annual Charges 1/	ANNUAL BENEFITS: Reduction of Flood Damages	Recreation: Directly Related	Recreation: Indirectly Related	Supplies of Water	Hydroelectric Power: Conventional	Hydroelectric Power: Pumped-Storage	Total
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
SMALL CONTROL PROJECTS										
Parkside		1,020	36	42	-	-	-	-	-	42
	12/	11	2	-	3	-	-	-	-	3
		1,030	38	42	3	-	-	-	-	45
Swiftwater		1,080	38	71	-	-	-	-	-	71
	12/	4	1	-	2	-	-	-	-	2
		1,080	39	71	2	-	-	-	-	73
Jim Thorpe		469	17	18	-	-	-	-	-	18
	12/	14	2	-	6	-	-	-	-	6
		483	19	18	6	-	-	-	-	24
36 small control projects listed in Table VII-1		7,060	260	457	-	-	-	-	-	457
Sub-Totals		9,630	351	587	-	-	-	-	-	587
	12/	28	4	-	11	-	-	-	-	11
		9,650	356	587	11	-	-	-	-	598
TOTAL ALL WATER CONTROL PROJECTS										
Major control projects		374,000	26,300	2,700	8,110	10,500	12,000	2,580	11,000	46,900
Major control projects to be developed in two stages		208,000	8,020	-	18,700	-	-	-	-	18,700
Small control projects		9,650	356	587	11	-	-	-	-	598
Totals		591,000	34,600	3,280	26,900	10,500	12,000	2,580	11,000	66,300

1/ Tentative annual costs based on uniform low-risk interest rate of 2.5 percent.
2/ Annual flood damage reduction of $295,000 is creditable to existing project.
3/ Additional cost for indirectly related recreation development.
4/ Annual flood damage reduction of $1,060,000 is creditable to existing project.
5/ Initial recreation development.
6/ Additional cost for acquisition of reservoir site.
7/ Value of acquisition of reservoir site not estimated.
8/ Additional cost indicative of possible magnitude of future reservoir construction.
9/ Not estimated because of distant construction date.
10/ Value applicable to acquisition of reservoir site and construction.
11/ Value of future water supply not estimated.
12/ Optional recreation development.

ited to the proposed projects were assumed equal to the average cost per unit of augmented flow thus defined with adjustments as indicated according to the geographic location of the project. Flow augmentation to be provided by each project is given in the project descriptions in chapter VII.

c. Recreation. Benefits for recreation were estimated on the basis of a constant unit value per visitor-day of increased annual attendance at the project locality. The value of $1.60 per visitor-day applied equally to all projects is a reflection of a weighted average visitor-day cost for a variety of recreation activities including picnicking, swimming, fishing, boating, camping, sightseeing, nature study, hunting, and other outdoor pursuits. Attendance estimates reflecting all of these activities are given for each project in the project description in chapter VII and summarized in table VIII-6. The basic recreation benefits credited to the eight major control projects to be developed initially for recreation were derived by procedures applicable to ultimate development. For initial development, without the major dam and reservoir, it was conservatively assumed that the annual recreation benefits would reflect a 40% reduction in annual visitation. The proposed initial development for recreation has the added advantage of assuring the availability of the storage potentials of these sites when their development for water supply is indicated. These assurances are of considerable value to the future economy of the basin and, while not included as benefits to the initial recreation development at these sites, they will be substantial and real. The omission of these benefits adds to the conservatism inherent in the economic evaluations presented in this report for the eight major control projects to be developed initially for recreation.

d. Fish and wildlife. Certain incidental benefits, over and beyond the fishing and hunting opportunities referred to in subparagraph c, above, are contemplated in connection with combined cold and warm water fisheries that would develop either within or below the projects. Monetary equivalents of such benefits were not established nor presented in appendix J. It is expected that the Fish and Wildlife Service will present such evaluations in an addendum to that appendix.

e. Power. Benefits for production of hydroelectric power were evaluated on the basis of the cost of the most likely alternatives, namely, privately-owned steam-electric plants. Unit annual values of capacity and energy in such alternates applied to the Tocks Island and Hawk Mountain Projects yielded the power benefits shown in table VIII-9 for these projects. The Department of the Interior indicated that the market can absorb the power to be developed at these two projects at the costs indicated in this report. (See exhibit A in appendix T.)

f. Navigation. The evaluation of possible benefits to navigation in the basin showed no significant benefits attributable at this time to the proposed major control projects. Also, because

of the peculiarities of the transport of fluvial sediment, no significant benefits could be claimed for reductions in the cost of maintenance dredging by reduced shoaling in existing navigable channels.

g. Pollution abatement. It was demonstrated in chapter VI that in this basin the present degree of sewage treatment and proposed programs for expansion thereof preclude the assignment of benefits to the major control projects on the basis of treatment foregone.

h. Detrimental project effects. In cases where construction or operation of any of the proposed projects will have detrimental or adverse effects, estimated monetary equivalents for such effects have been taken into account by suitable reductions in the benefits or by additions to the economic costs. Such adverse effects consist of the loss in taxes on property and productivity of lands preempted by the projects, which would otherwise accrue from alternate privately-operated facilities for production of power, relocations of homes, farms, industries and roads, and damages to the recreation, transportation, and fish and wildlife resources that would exist in the absence of the project.

i. Intangible benefits. In addition to the evaluated monetary benefits attributable to the control projects, other important benefits not susceptible of monetary evaluation will be realized. Among these are prevention of the loss of life from floods, geographical and aesthetic values associated with attractiveness of recreation development to promote optimum utilization of facilities provided therefor, and finally, the collective value of the balanced plan in serving a variety of comprehensive functions.

205. ECONOMIC JUSTIFICATION. Estimates of economic costs and benefits in table VIII-9 show that the annual benefits would exceed the tentative annual costs based on a uniform interest rate for each control project and for the projects considered as a system. In the case of the Prompton and Bear Creek Projects, proposed for modification to provide long-term storage, the economic justifications were based on the premise that the modification constituted a second stage of development and replacement to provide complete comprehensive development with a normal 50-year useful life expectancy. The magnitude of the excess annual benefits over the tentative annual costs in each case was sufficient to indicate justification under conditions of varying interest rates to be used subsequent to cost allocation and cost apportionment analyses.

206. ALLOCATION OF COSTS TO PROJECT PURPOSES. Allocation of costs for the multiple-purpose projects were made to indicate the equitable distribution of the costs among the several purposes served. All project costs were allocated by the separable costs-remaining benefits method over an amortization period of 50-years at an annual interest rate of 2-1/2 percent applied consistently throughout. This rate offers a simplified analysis based on a broad public viewpoint, wherein the project costs are allocated to the various purposes on the basis of a long-term average risk-free interest rate with an allowance

for the economic cost of land in testing for economic justification. In this procedure the borrowing rates would be introduced only after the apportionment of allocated costs for the purpose of defining financial costs. The details of the costs, benefits and procedures used in these allocations are presented in appendix V and summarized in table VIII-10. Costs of the modified Prompton and Bear Creek Projects were allocated in accordance with standard procedures using the cost of the original developments plus the cost of the proposed modifications.

207. The magnitude of flood control benefits attributable to each project will be a function of the time period over which these benefits accrue and the order in which the projects are developed. The flood control purpose within each project was evaluated with the project in logical time sequence and as the last unit constructed in the system. These studies demonstrated that the minimum benefits from reduction of flood damages based on these evaluations were of sufficient magnitude in each case to cover the incremental costs of including flood control facilities in the project.

208. APPORTIONMENT OF COSTS BETWEEN FEDERAL AND NON-FEDERAL INTERESTS. Sharing, between the Federal and non-Federal interests, of construction expenditures, annual operation and maintenance costs, and annual replacement costs is in accordance with established procedures. As will be discussed later in paragraph 215, all costs of the Hawk Mountain, Newark and Christiana Projects, and at the eight major control projects proposed for initial development for recreation are assigned to non-Federal interests since none of the purposes included in these projects at this time are normally considered the responsibility of the Federal government. The apportionments of costs to Federal and non-Federal interests for the eleven major control projects are shown in tablesVIII-11 and VIII-11a.

209. Apportionment of flood control costs. Costs allocated to flood control have been apportioned between Federal and non-Federal interests in accordance with the general policy expressed in the Flood Control Act of 1936 (Public Law 738, 74th Congress), as subsequently amended. In accordance with the expressed policy, the costs of providing flood control storage in major multiple-purpose projects have been apportioned to the Federal government on account of the widespread benefits associated with the flood control feature of these projects. When small flood control dams are provided, on the basis of cost, in lieu of local protection works, the benefits from these small dams are local in nature and local cooperation of the same type as for local protection works is required. Because of the local nature of the flood control benefits to be derived from the Parkside, Swiftwater, and Jim Thorpe Projects, and the remaining 36 small control projects, the non-Federal interests would have to meet certain requirements of local cooperation. For projects to be constructed under Public Law 685, non-Federal interests would be required

ALLOCATION OF COSTS FOR MAJOR CO
(in dollars)

(All amounts rounded; totals may not agree with sums

	Reduction of Flood Damage	Recreation Directly Related	Recreation Indirectly Related	Supplies of Water	Total	Reduction of Flood Damage
		PROMPTON				
1. BENEFITS	295,000 4/	130,000	118,000	307,000 3/	851,000	1,060,000 4/
2. ALLOCATION OF COSTS						
a. Annual Economic Costs	122,000	51,000	32,000	228,000	432,000	409,000
b. Annual O&M and Replacement Costs	10,000	19,000	17,000	54,000	101,000	31,000
c. Temporary Annual O&M and Repl. Costs 2/	23,000	22,000	17,000	38,000	101,000	58,000
d. Specific Use Construction Expenditures	-	427,000	387,000	-	814,000	-
e. Joint Use Facility Constr. Expenditures	2,860,000	254,000	-	4,500,000	7,620,000	10,100,000
f. Total Constr. Expenditures (First Cost)	2,860,000	681,000	387,000	4,500,000	8,430,000 5/	10,100,000
g. Cost of Existing Project	3,700,000	-	-	-	3,700,000	11,100,000
h. Total Constr. Expenditure without Rehabilitation Costs	-838,000	681,000	387,000	4,500,000	4,730,000	-951,000
i. Rehabilitation costs to extend economic life of existing flood control project for 50 years from time of modification.	620,000	-	-	-	620,000	4,460,000
j. Total New Construction Expenditures	-218,000	681,000	387,000	4,500,000	5,350,000	3,510,000
		AQUASHICOLA				
1. BENEFITS	293,000 3/	159,000	88,000	485,000 3/	1,030,000	114,000 3/
2. ALLOCATION OF COSTS						
a. Annual Economic Costs	271,000	94,000	26,000	435,000	826,000	97,000
b. Annual O&M and Replacement Costs	28,000	13,000	5,000	44,000	90,000	18,000
c. Temporary Annual O&M and Repl. Costs 2/	36,000	15,000	5,000	34,000	90,000	23,000
d. Specific Use Construction Expenditures	-	878,000	488,000	-	1,370,000	-
e. Joint Use Facility Constr. Expenditures	6,490,000	1,170,000	-	10,400,000	18,100,000	2,150,000
f. Total Construction Expenditures (First Cost)	6,490,000	2,050,000	488,000	10,400,000	19,500,000	2,150,000

						Reduction of Flood Damage
		BLUE MARSH				
1. BENEFITS	302,000 3/	217,000	477,000	531,000 3/	1,530,000	1,460,000 3/
2. ALLOCATION OF COSTS						
a. Annual Economic Costs	240,000	120,000	218,000	252,000	829,000	642,000
b. Annual O&M and Replacement Costs	36,000	36,000	68,000	38,000	179,000	58,000
c. Temporary Annual O&M and Repl. Costs 2/	45,000	39,000	68,000	26,000	179,000	75,000
d. Specific Use Construction Expenditures	-	1,500,000	3,290,000	-	4,780,000	-
e. Joint Use Facility Constr. Expenditures	5,140,000	457,000	-	5,410,000	11,000,000	14,200,000
f. Total Construction Expenditures (First Cost)	5,140,000	1,950,000	3,290,000	5,410,000	15,800,000	14,200,000

	Power	Recreation Directly Related	Supplies of Water	Total	Recreation Directly Related	Recreation Indirectly Related
		HAWK MOUNTAIN			NEW A	
1. BENEFITS	755,000	291,000	2,180,000 3/	3,230,000	876,000	606,000
2. ALLOCATION OF COSTS						
a. Annual Economic Costs	627,000	110,000	1,320,000	2,060,000	421,000	254,000
b. Annual O&M and Replacement Costs	151,000	44,000	97,000	291,000	127,000	90,000
c. Temporary Annual O&M and Repl. Costs 2/	-	not applicable		-		not appl
d. Specific Use Construction Expenditures	5,080,000	1,420,000	-	6,490,000	5,140,000	3,550,000
e. Joint Use Facility Constr. Expenditures	3,070,000	167,000	32,300,000	35,500,000	288,000	-
f. Total Constr. Expenditures (First Cost)	8,150,000	1,580,000	32,300,000	42,000,000	5,430,000	3,550,000

1/ Fish and wildlife benefits and costs discussed in Appendix J. No monetary equivalent given.
2/ Allocation for period of water supply deferral.
3/ Includes adjustments for projected flood plain developments and growth in water uses based on 2½ % interest rate.
4/ Creditable to existing project.
5/ Includes existing flood control project cost plus modification costs.
6/ Excludes pumped-storage hydropower.

TABLE VIII - 10

ALLOCATION OF COSTS FOR MAJOR CONTROL PROJECTS 1/
(in dollars)

ed; totals may not agree with sums of individual items due to rounding.)

...ies ...ater	Total	Reduction of Flood Damage (BEAR CREEK)	Recreation: Directly Related (BEAR CREEK)	Recreation: Indirectly Related (BEAR CREEK)	Supplies of Water (BEAR CREEK)	Total (BEAR CREEK)	Reduction of Flood Damage (BELTZVILLE)	Recreation: Directly Related (BELTZVILLE)	Recreation: Indirectly Related (BELTZVILLE)	Supplies of Water (BELTZVILLE)	Total (BELTZVILLE)
,000 3/	851,000	1,060,000 4/	161,000	236,000	1,300,000 3/	2,760,000	286,000 3/	174,000	618,000	669,000 3/	1,750,000
,000	432,000	409,000	60,000	69,000	404,000	940,000	206,000	94,000	72,000	328,000	700,000
,000	101,000	31,000	25,000	35,000	64,000	155,000	30,000	29,000	28,000	48,000	135,000
,000	101,000	58,000	27,090	35,000	34,000	155,000	41,000	33,000	28,000	34,000	135,000
-	814,000	-	595,000	875,000	-	1,470,000	-	1,290,000	1,190,000	-	2,470,000
,000	7,620,000	10,100,000	229,000	-	9,110,000	19,500,000	4,720,000	268,000	-	7,540,000	12,500,000
,000	8,430,000 5/	10,100,000	824,000	875,000	9,110,000	21,000,000 5/	4,720,000	1,550,000	1,190,000	7,540,000	15,000,000
-	3,700,000	11,100,000	-	-	-	11,100,000					
,000	4,730,000	-951,000	824,000	875,000	9,110,000	9,860,000					
-	620,000	4,460,000	-	-	-	4,460,000					
,000	5,350,000	3,510,000	824,000	875,000	9,110,000	14,300,000					

		TREXLER					MAIDEN CREEK				
5,000 3/	1,030,000	114,000 3/	281,000	215,000	464,000 3/	1,070,000	244,000 3/	424,000	568,000	833,000 3/	2,070,000
5,000	826,000	97,000	151,000	74,000	263,000	586,000	233,000	256,000	224,000	733,000	1,450,000
4,000	90,000	18,000	40,000	30,000	47,000	134,000	17,000	66,000	83,000	55,000	221,000
4,000	90,000	23,000	46,000	30,000	35,000	134,000	23,000	70,000	83,000	44,000	221,000
-	1,370,000	-	1,500,000	1,140,000	-	2,640,000	-	2,440,000	3,250,000	-	5,690,000
0,000	18,100,000	2,150,000	653,000	-	5,770,000	8,570,000	5,610,000	1,700,000	-	17,800,000	25,200,000
0,000	19,500,000	2,150,000	2,150,000	1,140,000	5,770,000	11,200,000	5,610,000	4,140,000	3,250,000	17,800,000	30,800,000

		Reduction of Flood Damage	Recreation: Directly Related	Recreation: Indirectly Related	Supplies of Water	Power Conventional	Total
		TOCKS ISLAND 6/					
,000 3/	1,530,000	1,460,000 3/	3,660,000	6,340,000	3,800,000 3/	1,820,000	17,100,000
,000	829,000	642,000	1,730,000	2,500,000	1,270,000	1,420,000	7,560,000
,000	179,000	58,000	582,000	971,000	98,000	257,000	1,970,000
,000	179,000	75,000	615,000	971,000	20,000	284,000	1,970,000
-	4,780,000	-	18,200,000	31,600,000	-	12,300,000	62,200,000
,000	11,000,000	14,200,000	8,370,000	-	28,500,000	9,130,000	60,200,000
,000	15,800,000	14,200,000	26,600,000	31,600,000	28,500,000	21,500,000	122,000,000

...tal	Recreation: Directly Related (NEWARK)	Recreation: Indirectly Related (NEWARK)	Supplies of Water (NEWARK)	Total (NEWARK)	Recreation: Directly Related (CHRISTIANA)	Recreation: Indirectly Related (CHRISTIANA)	Supplies of Water (CHRISTIANA)	Total (CHRISTIANA)
30,000	876,000	606,000	794,000 3/	2,280,000	1,730,000	1,240,000	639,000 3/	3,610,000
50,000	421,000	254,000	435,000	1,110,000	614,000	424,000	491,000	1,530,000
91,000	127,000	90,000	63,000	280,000	241,000	179,000	61,000	482,000
-		not applicable				not applicable		
90,000	5,140,000	3,550,000	-	8,690,000	7,560,000	5,420,000	-	13,000,000
00,000	288,000	-	9,830,000	10,100,000	213,000	-	10,300,000	10,500,000
00,000	5,430,000	3,550,000	9,830,000	18,800,000	7,780,000	5,420,000	10,300,000	23,500,000

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TABLE VIII-11

APPORTIONMENT OF COSTS TO FEDERAL AND NON-FEDERAL INTERESTS - MAJOR CONTROL PROJECTS 1/
(in dollars)

(All amounts rounded; totals may not agree with sums of individual items due to rounding.)

APPORTIONMENT OF COSTS	PROMPTON Federal	PROMPTON Non-Federal	PROMPTON Total	TOCKS ISLAND 3/ Federal	TOCKS ISLAND 3/ Non-Federal	TOCKS ISLAND 3/ Total
1. Total Construction Expenditures	463,000	4,890,000	5,350,000 2/	93,900,000	28,500,000	122,000,000
2. Annual O.& M. and Replacement Costs	29,000	72,000	101,000	1,870,000	98,000	1,970,000
3. Temporary Annual O.& M. and Replacement Costs 4/	45,000	55,000	101,000	1,950,000	20,000	1,970,000
4. Apportionment of Construction Expenditures for Fish and Wildlife Facilities	not applicable			1,320,000	1,180,000	2,500,000

APPORTIONMENT OF COSTS	BEAR CREEK Federal	BEAR CREEK Non-Federal	BEAR CREEK Total	BELTZVILLE Federal	BELTZVILLE Non-Federal	BELTZVILLE Total
1. Total Construction Expenditures	4,330,000	9,990,000	14,300,000 2/	6,280,000	8,720,000	15,000,000
2. Annual O.& M. and Replacement Costs	55,000	99,000	155,000	59,000	76,000	135,000
3. Temporary Annual O.& M. and Replacement Costs 4/	85,000	70,000	155,000	74,000	62,000	135,000

APPORTIONMENT OF COSTS	AQUASHICOLA Federal	AQUASHICOLA Non-Federal	AQUASHICOLA Total	TREXLER Federal	TREXLER Non-Federal	TREXLER Total
1. Total Construction Expenditures	8,540,000	10,900,000	19,500,000	4,300,000	6,910,000	11,200,000
2. Annual O.& M. and Replacement Costs	40,000	50,000	90,000	57,000	77,000	134,000
3. Temporary Annual O.& M. and Replacement Costs 4/	51,000	39,000	90,000	69,000	66,000	134,000

APPORTIONMENT OF COSTS	MAIDEN CREEK Federal	MAIDEN CREEK Non-Federal	MAIDEN CREEK Total	BLUE MARSH Federal	BLUE MARSH Non-Federal	BLUE MARSH Total
1. Total Construction Expenditures	9,750,000	21,100,000	30,800,000	7,100,000	8,700,000	15,800,000
2. Annual O.& M. and Replacement Costs	83,000	138,000	221,000	72,000	106,000	179,000
3. Temporary Annual O.& M. and Replacement Costs 4/	94,000	127,000	221,000	85,000	94,000	179,000

APPORTIONMENT OF COSTS	HAWK MOUNTAIN Non-Federal	HAWK MOUNTAIN Total	NEWARK Non-Federal	NEWARK Total	CHRISTIANA Non-Federal	CHRISTIANA Total
1. Total Construction Expenditures	42,000,000	42,000,000	18,800,000	18,800,000	23,500,000	23,500,000
2. Annual O.& M. and Replacement Costs	291,000	291,000	280,000	280,000	482,000	482,000
3. Temporary Annual O.& M. and Replacement Costs 4/	not applicable		not applicable		not applicable	

1/ Includes costs for indirectly related recreation.
2/ Modification costs plus rehabilitation costs.
3/ Exclusive of pumped-storage hydropower development.
4/ Allocation for period of water supply deferral.

TABLE VIII-11a

APPORTIONMENT OF COSTS TO FEDERAL AND NON-FEDERAL INTERESTS - TOCKS ISLAND PROJECT 1/
(in dollars)

(All amounts rounded; totals may not agree with sums of individual items due to rounding.)

	TOCKS ISLAND 2/			TOCKS ISLAND 3/		
	Federal	Non-Federal	Total	Federal	Non-Federal	Total
APPORTIONMENT OF COSTS						
1. Total Construction Expenditures	92,600,000	84,700,000	177,000,000	153,000,000	24,000,000	177,000,000
2. Annual O&M and Replacement Costs	1,850,000	3,780,000	5,630,000	5,550,000	86,000	5,630,000
3. Temporary Annual O&M and Replacement Costs 4/	1,900,000	3,730,000	5,630,000	5,630,000	-	5,630,000
4. Apportionment of Construction Expenditures for Fish and Wildlife Facilities	1,240,000	1,260,000	2,500,000	1,520,000	980,000	2,500,000

1/ Includes costs for indirectly related recreation
2/ Includes pumped-storage hydropower development by non-Federal interests.
3/ Includes pumped-storage hydropower development by Federal interests.
4/ Allocation for period of water supply deferral.

to: (a) provide lands, easements, and rights-of-way; (b) hold and save the United States free from damages due to the construction work; and (c) agree to maintain and operate the works upon completion. For projects to be constructed under Public Law 566, non-Federal interests would be required to: (a) provide lands, easements, and rights-of-way; (b) assume such proportionate share of the cost of construction as may be equitable; (c) assume the costs of operating and maintaining the works after completion; (d) acquire such water rights as may be needed for the project; and (e) obtain agreements to carry out recommended soil conservation measures and proper farm plans from owners of not less than 50 percent of the lands situated in the drainage area above each retention reservoir.

210. Apportionment of recreation costs. The apportionments of specific and allocated joint recreation costs are in accordance with the general policy expressed in Section 4 of the Flood Control Act of 1944 (Public Law 534, 78th Congress). The portion of those specific costs, including operation, maintenance and replacement costs, required to serve the recreation purposes directly associated with the multiple-purpose projects, will be borne by Federal interests. However, at the time of construction local interests should be encouraged to assume part or all of the specific operation, maintenance and replacement costs for recreation at the various multi-purpose projects. In addition to the apportioned specific costs, the Federal interests would bear joint costs allocated to recreation in an amount not to exceed 15 percent of the total project costs. For all projects where this provision is applicable, the allocated joint costs for recreation fall within this 15 percent limitation. Those specific recreation costs required for the complete development of each project's recreation potential, over and above those costs for the recreation purpose directly associated with the multiple-purpose projects, are assigned to non-Federal interests.

211. In recognition of the findings of this investigation, as expressed in appendices I and W, that the recreation benefits at the Tocks Island Project have widespread regional and national significance, all specific and allocated recreation costs are generally assigned to Federal interests. All recreation specific and allocated joint costs for recreation development at the Hawk Mountain, Newark and Christiana Projects, and at the eight major control projects to be developed initially for recreation are assigned to non-Federal interests. The apportionment of recreation costs to Federal and non-Federal interests for each major control project is given in table VIII-12.

TABLE VIII-12

APPORTIONMENT OF SPECIFIC AND ALLOCATED JOINT RECREATION COSTS - MAJOR CONTROL PROJECTS 1/
(in dollars)

(All amounts rounded; totals may not agree with sums of individual items due to rounding)

APPORTIONMENT OF COSTS	PROMPTON Federal	PROMPTON Non-Federal	PROMPTON Total	TOCKS ISLAND 3/ Federal	TOCKS ISLAND 3/ Non-Federal	TOCKS ISLAND 3/ Total	BEAR CREEK Federal	BEAR CREEK Non-Federal	BEAR CREEK Total
1. Specific Construction Expenditures	427,000	387,000	814,000	49,800,000	-	49,800,000	595,000	875,000	1,470,000
2. Joint-Use Facility Construction Expenditures allocated to Recreation	254,000	-	254,000	8,370,000	-	8,370,000	229,000	-	229,000
3. Total Construction Expenditures	681,000	387,000	1,070,000	58,200,000	-	58,200,000	824,000	875,000	1,700,000
4. Specific Annual O.& M. and Replacement Costs	18,000	17,000	35,000	1,530,000	-	1,530,000	23,000	35,000	58,000
5. Joint Annual O.& M. allocated to Recreation	1,000	-	1,000	23,000	-	23,000	1,000	-	1,000
6, Total Annual O.& M. and Replacement Costs	19,000	17,000	36,000	1,560,000	-	1,560,000	25,000	35,000	60,000
7. Temporary Annual O.& M. and Replacement Costs 2/	22,000	17,000	39,000	1,590,000	-	1,590,000	27,000	35,000	62,000

APPORTIONMENT OF COSTS	BELTZVILLE Federal	BELTZVILLE Non-Federal	BELTZVILLE Total	AQUASHICOLA Federal	AQUASHICOLA Non-Federal	AQUASHICOLA Total	TREXLER Federal	TREXLER Non-Federal	TREXLER Total
1. Specific Construction Expenditures	1,290,000	1,190,000	2,470,000	878,000	488,000	1,370,000	1,500,000	1,140,000	2,640,000
2. Joint-Use Facility Construction Expenditures allocated to Recreation	268,000	-	268,000	1,170,000	-	1,170,000	653,000	-	653,000
3. Total Construction Expenditures	1,550,000	1,190,000	2,740,000	2,050,000	488,000	2,540,000	2,150,000	1,140,000	3,290,000
4. Specific Annual O.& M. and Replacement Costs	28,000	28,000	55,000	8,000	5,000	13,000	34,000	30,000	64,000
5. Joint Annual O.& M. allocated to Recreation	2,000	-	2,000	5,000	-	5,000	5,000	-	5,000
6. Total Annual O.& M. and Replacement Costs	30,000	28,000	57,000	13,000	5,000	18,000	40,000	30,000	70,000
7. Temporary Annual O.& M. and Replacement Costs 2/	33,000	28,000	60,000	15,000	5,000	21,000	46,000	30,000	76,000

APPORTIONMENT OF COSTS	MAIDEN CREEK Federal	MAIDEN CREEK Non-Federal	MAIDEN CREEK Total	BLUE MARSH Federal	BLUE MARSH Non-Federal	BLUE MARSH Total
1. Specific Construction Expenditures	2,440,000	3,250,000	5,690,000	1,500,000	3,290,000	4,780,000
2. Joint-Use Facility Construction Expenditures allocated to Recreation	1,700,000	-	1,700,000	457,000	-	457,000
3. Total Construction Expenditures	4,140,000	3,250,000	7,390,000	1,950,000	3,290,000	5,240,000
4. Specific Annual O.& M.and Replacement Costs	61,000	83,000	144,000	33,000	68,000	101,000
5. Joint Annual O.& M. allocated to Recreation	5,000	-	5,000	3,000	-	3,000
6. Total Annual O.& M. and Replacement Costs	66,000	83,000	149,000	36,000	68,000	104,000
7. Temporary Annual O.& M. and Replacement Costs 2/	70,000	83,000	154,000	39,000	68,000	107,000

APPORTIONMENT OF COSTS	HAWK MOUNTAIN Non-Federal	HAWK MOUNTAIN Total	NEWARK Non-Federal	NEWARK Total	CHRISTIANA Non-Federal	CHRISTIANA Total
1. Specific Construction Expenditures	1,420,000	1,420,000	8,690,000	8,690,000	13,000,000	13,000,000
2. Joint-Use Facility Construction Expenditures allocated to Recreation	167,000	167,000	288,000	288,000	213,000	213,000
3. Total Construction Expenditures	1,580,000	1,580,000	8,980,000	8,980,000	13,200,000	13,200,000
4. Specific Annual O.& M. and Replacement Costs	42,000	42,000	213,000	213,000	416,000	416,000
5.Joint Annual O.& M. allocated to Recreation	1,000	1,000	4,000	4,000	5,000	5,000
6. Total Annual O.& M. and Replacement Costs	44,000	44,000	217,000	217,000	420,000	420,000
7. Temporary Annual O.& M. and Replacement Costs 2/	not applicable		not applicable		not applicable	

1/ Non-Federal costs reflect indirectly related recreation. At Tocks Island both directly and indirectly related recreation are apportioned to the Federal interest.

2/ Allocation for period of water supply deferral.

3/ Apportionment applicable for development of project without pumped-storage hydropower.

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212. Apportionment of water supply costs. In accordance with the provisions of the Water Supply Act of 1958 (Title III, Public Law 500, 85th Congress), all costs allocated to the supplies of water for municipal, industrial, and rural uses from storage in multiple-purpose projects are the responsibility of non-Federal interests. These allocated costs include all costs for reservoir storage required for supplies of water by local interests at the time the project is initiated as well as the supplies of water for anticipated future demands during the life of the project. Payment of first costs allocated to storage for current water supply use can be made by local interests either in lump sum at the time of construction or on an annual payment basis. In the case of costs incurred for provision of future supplies of water, repayment by local interests of first costs need not be initiated until reservoir capacity is first used for storage of water for water supply purposes. In this latter case no interest need be paid by local interests on the costs for future supplies of water until such use is initiated but such interest-free period shall not exceed ten years from the time the project is constructed. Operation, maintenance and replacement costs also are divided into those incurred for provisions for current and future water supplies. Local responsibility for operation, maintenance and replacement costs associated with storage for current use begins upon completion of the project. Local responsibility for these costs associated with storage for future use begins with the first use of this storage for the storage of water for water supply purposes.

213. Apportionment of hydropower costs. Specific and allocated joint costs for conventional hydroelectric power at the Tocks Island Project are apportioned to the Federal interests. The pumped-storage power facilities at this site are suitable for development as either a Federal or a non-Federal project. For this reason, specific and joint costs for the facilities have been computed as apportioned to either Federal or non-Federal interests. By sharing in the joint costs of the Tocks Island reservoir project, the pumped-storage installation would decrease the cost of other functions of the Tocks Island development. The specific and allocated joint costs for conventional power at the Hawk Mountain Project are also apportioned to non-Federal interests.

214. Apportionment of costs of fish and wildlife facilities. Specific costs in the amount of $2,500,000 for facilities to pass fish at the Tocks Island dam are included in cost estimates for that project. These specific costs are treated as joint costs and are allocated between other project purposes. Their ultimate distribution between Federal and non-Federal interests thus is in proportion to the overall division of the joint costs between these interests.

215. Other apportionments of cost. General definitions of the Federal interest in the municipal and industrial water supply and recreational aspects of reservoir development are given in the Water Supply Act of 1958 and the Flood Control Act of 1944, as amended, respectively. These Acts relate the Federal interest in these functions to development of Federal projects for such purposes as navigation, flood control and irrigation. Federal interest in the hydroelectric power aspects of reservoir development has been determined on the same basis. Because purposes necessary to the establishment of a basic Federal interest could not be justified and are not included in the case of the Newark, Christiana, and Hawk Mountain Projects and the eight projects proposed to be developed initially for recreation, it is appropriate that these projects be undertaken by non-Federal interests. The costs are assigned accordingly.

216. BENEFIT-COST RATIOS. After completion of allocation and apportionment studies, benefit-cost ratios were computed for the water control projects in the plan of development and for the entire system by comparing the annual benefits and annual charges based on the following probable borrowing rates:

Investment	Annual Interest Rate Percent	Remarks
Federal	2-5/8	-Applicable to reduction of flood damages, recreation and power.
Non-Federal - Federally financed	2-5/8	-Applicable to future water supply costs.
Public	3	-Applicable to recreation.
	4	-Applicable to water supply required at completion of the project.
Private	6	-Applicable to power.

In order to be consistent with the use of the current 2-5/8% risk-free interest rate for Federal investment now introduced, the discounting of future flood control and water supply benefits, previously discussed in paragraph 204, was recomputed on the basis of this rate. Total annual charges consist of construction expenditures, including allowances for the economic cost of lands, reduced to annual investment costs by the application of appropriate interest rates; annual operation, maintenance and replacement costs; and allowances for taxes foregone. The interest rates for non-Federal and private investments were based on the current long-term borrowing rates for similar type investments and are used for comparative purposes in the development of overall benefit-

cost ratios. The resulting benefit-cost ratios are given in table VIII-13.

217. In computing annual investment for water supply, that portion of the cost of storage for future water supply, up to 30 percent of the total construction expenditures, is considered to be repayment of Federal investment at an interest rate of 2-5/8 percent. The remaining construction expenditure for water supply storage is amortized at a 4 percent interest rate. In the Maiden Creek Project the cost assigned to water supplies for current use would be sufficient to pay for water supply storage to satisfy the needs for a period greater than the 10-year interest-free period. For this case, the interest at 2-5/8 percent for future water supply during the period from 10 years until the anticipated demand indicates the water will be required, is added to the non-Federal storage costs for future water supply.

218. **LOCAL COOPERATION IN THE PLAN OF DEVELOPMENT**. The extent to which local interests are required to cooperate financially is defined above in the apportionment of non-Federal costs. The full realization of the potentials of the water resources of the basin requires related programs of land and water management. It is necessary that local interests sustain and vigorously pursue such programs.

TABLE VIII-13
BENEFIT-COST RATIOS FOR WATER CONTROL PROJECTS
IN PLAN OF DEVELOPMENT
(All benefit and cost amounts are rounded)

Project	Total Annual Project Benefits	Total Annual Economic Costs	Benefit-Cost Ratio
MAJOR CONTROL PROJECTS 1/			
Hawk Mountain	$3,220,000	$2,760,000	1.2
Prompton 2/	486,000	348,000	1.4
Tocks Island*(without pumped-storage)	17,100,000	7,700,000	2.2
Bear Creek 2/	1,880,000	714,000	2.6
Beltzville	1,130,000	682,000	1.7
Aquashicola	936,000	874,000	1.1
Trexler	858,000	552,000	1.6
Maiden Creek	1,490,000	1,390,000	1.1
Blue Marsh	1,050,000	642,000	1.6
Newark	1,670,000	997,000	1.7
Christiana	2,370,000	1,260,000	1.9
MAJOR CONTROL PROJECTS TO BE DEVELOPED IN TWO STAGES - DATA PERTINENT TO FIRST-STAGE DEVELOPMENT FOR RECREATION 3/			
Paulina	960,000	766,000	1.3
Pequest	499,000	350,000	1.4
Hackettstown	2,400,000	1,420,000	1.7
New Hampton	1,440,000	1,040,000	1.4
Tohickon	1,200,000	898,000	1.3
Newtown	1,800,000	1,970,000	0.9
French Creek	1,440,000	876,000	1.6
Evansburg	1,500,000	1,170,000	1.3
SMALL CONTROL PROJECTS			
Parkside (Pc-8) 4/	42,000	37,000	1.1
Swiftwater (Pc-9) 4/	71,000	39,000	1.8
Jim Thorpe (Hz-6) 4/	18,000	17,000	1.03
36 Projects	457,000	266,000	1.7
TOTAL: ALL PROJECTS IN PLAN	44,000,000	26,800,000	1.6
*Tocks Island (with non-Federal development of pumped-storage)	28,100,000	18,100,000	1.6
*Tocks Island (with Federal development of pumped-storage)	28,100,000	16,300,000	1.7

1/ Benefits and costs for indirectly related recreation included in the case of Tocks Island only.

2/ Benefits and costs for new construction expenditures at existing project.

3/ Costs include lands and facilities for recreational development and land acquisition for dam and reservoir. Benefits are related to recreational development only and do not include values related to site preservation.

4/ Benefits and costs for incidental recreation use not included.

CHAPTER IX

IMPLEMENTATION AND USE OF PLAN

219. INTRODUCTION. The development of the program of improvements will require an orderly sequence in the construction of water control projects and the timely prosecution of the related programs. The implementation of this plan will require the active participation of Federal and non-Federal interests in the sharing of financial responsibilities and obligations, in initiating the required related resource programs, in continually reassessing and evaluating the needs and measures for water resource development, and in the coordination needed for operation of the elements of the plan.

220. SCHEDULE FOR PROJECT DEVELOPMENT. The selection of the time sequence and order of development for the major water control elements of this plan was primarily based on the projected time pattern of water resource product demands and the geographic distribution of these demands throughout the basin. It has been shown that major markets presently exist for the additional production of such goods and services as the reduction of flood damages, recreation, fish and wildlife, electric energy, and for supplies of water. These markets, as projected to the year 2010, will expand at a rate corresponding to the accelerated overall growth rate projected for the economic activity in the Delaware River Water Service Area. The schedule and sequence presented below for the eleven major control projects was established on a basis consistent with the present and projected future expansion of product markets. This sequence has been designed to minimize the effects of delayed production of products for which markets may presently exist. The sequence was designed, also, to avoid the production of water resource derivatives, such as supplies of water, for which substantial markets would not become fully effective for some years in the future.

Order of Project Development	Year Required
Beltzville	1965
Blue Marsh	1969
Trexler	1972
Prompton 1/	1974
Newark	1975
Tocks Island	1975
Christiana	1980
Aquashicola	1981
Maiden Creek	1982
Bear Creek 1/	1989
Hawk Mountain	2001

1/ Modification of existing project

The dates specified in the above sequence are flexible and subject to adjustments depending upon continued planning evaluations of the future requirements for supplies of water and other water resource derivatives. The dates specified for the Newark and Christiana Projects are flexible with respect to proposed developments in the Upper Brandywine Basin. The order of development itself possesses additional flexibility in that certain projects may be shifted without seriously changing the required pattern for the production of the water resource products. For example, the Beltzville, Trexler, and Aquashicola Projects may be exchanged for each other in the above sequence. Similarly, the Blue Marsh and Maiden Creek Projects may be interchanged timewise, as is the case, also, for the Newark and Christiana Projects.

221. With regard to the Paulina, Pequest, Hackettstown, New Hampton, Tohickon, Newtown, French Creek and Evansburg Projects intended to serve essentially the needs of recreation and supplies of water, no precise schedule nor sequence has been established at this time. Prior to the time that these projects will be required for supplies of water, subsequent to 2010, land would be acquired at these sites, as it becomes available, to permit needed recreation development. When the needs arise full multiple-purpose potentials can be realized by second stages of development. The construction of the 39 small impoundment projects located on the intermediate upstream tributaries should be at the earliest possible date consistent with fund availability and with local cooperation and participation in accordance with existing programs and authorities. These projects should be developed as soon as possible for reduction of flood damages present in the areas immediately downstream from these projects, and for water supply and other purposes as desired by local interests.

222. In the actual development of the major elements of the plan for the control and utilization of the basin's water resources it must be borne in mind that the sequence and timing indicated in this investigation were based on considerations that depended heavily on generalized projections of the needs for products and services to be gleaned from that development. The project dimensions and uses depend to a lesser extent on those projections. While the projections are based on the best information currently available on probable long-range trends, it is recognized that their dependableness and accuracy will vary inversely with the length of the period of the projections. It is to be expected that the definition of needs during the latter half of the 50-year period of projection used in this investigation would need to be re-examined before continuing with the development of the plan after, say, year 1985. Such re-examination could result in major modification in the use of projects previously provided and in the projects proposed for development in the period 1985 to 2010.

Since the proposed plan of major control structures will provide a sound basis for long range development it would seem prudent to limit present proposals for Federal participation to those elements of the plan that current and projected needs indicate should be developed in the next 20 to 25 years. The Bear Creek Project, however, for which need is indicated by the year 1989, has aspects which warrant its inclusion in the proposed program for authorization. These aspects are: (a) the definite establishment of the project site and physical potential for improvement by existing construction; (b) the very attractive incremental economics of modification; and (c) the desirability of extending, to the Bear Creek site, any site preservation procedures which may be adopted.

223. PRESERVATION OF RESERVOIR SITES. The actual development of the program of improvements will depend on the availability of the project areas for timely development and use. Because of generally uncontrolled land uses that prevail in the basin, there can be no assurance of the availability of the sites for reservoir purposes at anticipated future time of need unless positive steps are taken to preserve the areas for that specific use. Such steps may affect the eventual cost of the projects and will most certainly be complicated and involved. For example, acquisition, options or easements may be indicated in some instances, and these entail consideration of leaseback and controlled development of the lands being preserved. Furthermore, dam sites proposed in survey scope investigations are apt to be changed a reasonable distance upstream or downstream as the result of detailed site studies made in connection with preconstruction investigations. From consideration of the factors involved it appears that the most practical means of preserving the reservoir sites would require: (a) that the dam sites be firmly fixed by detailed site investigations immediately following project authorization; (b) land acquisition programs, based on detailed dam site surveys and project land needs, be initiated as soon as practical and pursued in an orderly manner until the preservation of the reservoir site is assured; (c) leaseback or other types of programs designed to keep the acquired lands in productive use until they are needed for reservoir purposes and (d) programs to mitigate the effects of the land acquisition program on the taxing structure and incomes of such governmental units as school districts, townships and counties.

224. IMPLEMENTATION OF RELATED PROGRAMS. The related programs needed to supplement and complement the major physical elements of the water control plan are not susceptible of precise scheduling. Most of these programs are currently operative and effective in the areas of land management, controlling the use of flood plains, preservation of recreation, fish and wildlife resources, the abatement of pollution, and improvement of

water quality. These programs must be vigorously pursued in the future and be responsive to their unique role in satisfying those water resource needs that cannot be fully satisfied through reservoirs alone either because it would be uneconomic to do so or the satisfaction of such needs are beyond the scope of water control alone. The nature of this planning effort, in providing a guide for water resources development for a river basin encompassing a broad geographic area and economic base, for a planning period of 50-years, requires periodic review to adjust to conditions as they develop or can be more firmly projected. This will require continuous and active participation of local interests. The variety and scope of the related programs will necessitate further participation, essentially by local interests. As elements of the plan become operative their role in the overall resource programs of the area will require reappraisal at timely intervals.

225. COORDINATION OF INTERESTS. The comprehensive nature of the proposed plan of development for the water resources of the Delaware River Basin embraces a number of water control measures and resource programs, serves a variety of functions, and requires financial and program participation by Federal and non-Federal interests. As a means for coordinating and integrating these interests the local agencies of the area are currently considering the nature and establishment of an appropriate organization. One form of organization designed to accomplish this is presented in appendix X to this report.

CHAPTER X
SALT WATER BARRIER STUDY

226. PURPOSE. Pursuant to the resolution adopted by the Committee on Public Works of the United States Senate on 28 April 1958, a preliminary analysis was made of the economic feasibility of constructing a salt water barrier in the Delaware River estuary with a view to determining whether there was justification for making detailed studies of all aspects of such a proposal. Details of the analysis that was made are contained in appendix S.

227. SCOPE OF STUDIES. The work required for the analysis fell into the categories of: (a) field investigations; (b) model tests; and (c) office studies. The field work consisted of reconnaissance and inspection of possible project site locations. Model tests were made to determine the best type of barrier and its effects on tides, currents and salinity. The office studies included: (a) the analysis of data on future water requirements; (b) analysis of the effect a barrier would have on existing improvements, fish and wildlife resources, recreation, shore lines, flooding from hurricane surges; (c) preliminary design of the barrier, locks and other required facilities; (d) consideration of other possible sources of fresh water in lieu of that to be provided by the barrier; and (e) an economic analysis from which conclusions were drawn.

228. SITE SELECTION. The location for the barrier had to be such that its construction would result in a large body of fresh water to provide a water supply for northern Delaware. It was also desirable to place the barrier north of the entrance to the Chesapeake and Delaware Canal in order that the tidal regimen of this sea-level waterway would not be radically changed. Consideration of these factors placed the barrier in the New Castle-Delaware City area. Three sites in this area were considered and the site adopted was chosen because; (a) it provides vessels the best approaches to the locks; (b) it provides minimum width of river for barrier construction; and (c) it involves minimum interference with existing improvements.

229. MODEL STUDIES. To determine the type of barrier that would effectively stop the intrusion of salt water, tests were made in the model of the Delaware River at the Waterways Experiment Station. Details of these tests are contained in appendix S. Two plans with different types of barriers were tested at the same location in the model. Plan A consisted of a barrier with a navigation opening 500 feet wide at elevation minus 40 (Delaware River datum), to permit the passage of vessels, and a spillway 4,000 feet long with a crest at elevation 6.0 for the passage of peak fresh water flows. Plan B consisted of a barrier with four navigation locks for the passage of vessels, and a spillway 4,000 feet long with a crest at elevation 8.0 to prevent overtopping by tides.

230. The model tests showed that the barrier in Plan A, having an ungated opening, would have no beneficial effects on salinity upstream of the barrier site, because the upstream limit of salinity intrusion would not be reduced. In the case of Plan B, the tests showed that the barrier would cause more extensive salinity intrusion than is the case under existing conditions unless means were provided for removal of salt water which would enter the upper pool during each ship transit through the locks. Plan B, the barrier with locks, was therefore modified by the addition of a scavenger sump in the upper pool with a gravity drain. Tests showed that this modified plan would effectively control salinity intrusion into the upper pool.

231. Tests in the model also showed that any barrier that obstructed the tidal wave in the estuary to an appreciable degree would cause drastic changes in the tidal regimen. The barrier with navigation locks, as demonstrated by the effects of Plan B, would cause the maximum change in tidal regimen.

232. PLAN OF IMPROVEMENT. On the basis of the results of the model tests, the type of barrier in Plan B, modified, was adopted for the plan of improvement. The site selected for the barrier in this plan is located a short distance downstream from New Castle, Delaware.

233. STRUCTURES. The structures in the plan of improvement consist of levees, earth embankments, locks, spillway, a concrete transition between spillway and locks, and a sump and drain system. The levee sections would be built across the land areas and marshes requiring diking. The embankment sections would be located across the shallower portions of the river near the shores. The lock section would contain four locks, two large ones and two small ones, located symmetrically about a center island, on which would be placed the control tower, administration building and maintenance shops. One large lock would be located along each side of the center island and one small lock would be located along the outer side of each large lock. The spillway would be a concrete gravity section 4,705 feet in length, with the crest at elevation 6.0 and crest gates to provide a closure to elevation 28.0. A non-overflow concrete gravity section 620 feet long would provide a transition between the lock and spillway sections. A fish ladder would probably be required if a solid barrier is constructed. The top elevation of the barrier would be 28.0 and its full length would be about 53,300 feet. The large locks would be 1,200 feet long and 170 feet wide, and provide a depth of 50 feet over the sills. The small locks would be 500 feet long and 80 feet wide, and provide a depth of 35 feet over the sills. The scavenger sump, to collect intruding salt water, would be 2,000 feet long, 800 feet wide, with a bottom elevation of minus 50, and would be located on the channel center line about 5,000 feet upstream of

the barrier. A gravity drain from the bottom of the sump would carry the collected salt water to the downstream side of the barrier.

234. PHYSICAL EFFECTS. A barrier in the Delaware River estuary would produce various and far-reaching effects on existing physical characteristics. Some of the physical effects would generate economic effects.

235. The primary purpose of the proposed barrier is to prevent the intrusion of salt water and to create a source of fresh water supply in the vicinity of northern Delaware. Model tests have demonstrated that the type of barrier, with a scavenger sump, presented in the plan of improvement would probably effectively control the intrusion of salt water into the upper pool.

236. Tidal action of the Delaware Estuary would be affected by the barrier; the tide would be eliminated above the barrier and the magnitude and timing of tides would be changed below the barrier. Elimination of the tide above the barrier would also eliminate the currents developed by the rise and fall of tides in this reach of the river. Just downstream from the barrier the range of tide would be increased by about 3.8 feet and the times of high and low tides would be advanced by about one hour. Model tests showed that immediately below the dam site, the elevation of low tide would be lowered by about two feet, and the elevation of high tides would be increased by about 1.8 feet. At all stations below the barrier tidal current velocities would be reduced, indicating that the tidal prism would be reduced appreciably.

237. Upstream of the barrier the water level in the pool would be stabilized at about the present plane of mean high water. During floods, or freshets, the stage would be higher than the present mean high water level. A constant pool level above the barrier would: (a) stabilize the shore line; (b) eliminate tidal marshes and mud flats; (c) affect many shore structures, storm drains and sewage systems; (d) limit vertical clearances under bridges to those now existing at mean high water; (e) provide additional depth of water for navigation in channels of the Delaware and its tributaries and allow deeper draft vessels to utilize these channels at all times; and (f) eliminate delays caused by deep-draft vessels awaiting high tide in order to get enough depth to bring the vessels into the port area. On the other hand navigation would be adversely affected because of delays that would be associated with passage through the locks. A barrier in the estuary would restrict free passage of migratory fish in the river, and permanent flooding of tidal marshes and the elimination of saline water from the area above

the barrier would have some beneficial and some detrimental effects on wildlife.

238. In addition to the above, many other changes in the physical characteristics of the estuary would result. The more prominent among these are as follows: (a) shoaling rates and locations where shoaling occurs would be changed due to the elimination of tidal currents in the pool above the barrier and due to the reduction in tidal currents downstream from the barrier; (b) the levels of ground water tables would be raised by the constant high water pool behind the barrier; (c) the temperature of the water in the reaches behind the barrier would be raised due to the elimination of the tidal currents which have a flushing effect that changes the water and keeps the temperature of the water uniform as determined by prevailing weather conditions; (d) the quality of the water behind the pool would be adversely affected by the elimination of the tidal currents; (e) conditions more favorable to the formation of ice would be produced by the elimination of tidal effects and reduction in salinity above the pool; and (f) the downstream passage of ice would be obstructed by the barrier.

239. COSTS. Refined and detailed estimates of cost were not warranted for this proposed project because it was apparent that alternative developments for satisfying the water supply needs of northern Delaware were more economical. Therefore estimates of probable first costs, of preliminary scope, were prepared for appraising the feasibility of developing a favorable barrier project. The preliminary total first cost of the barrier, including facilities required for navigation, is estimated to be about $345,000,000, based on January 1960 price levels. In order to use the barrier pool as a source of water supply, intake and water transmission facilities would need to be constructed. With the intake located near New Castle, a pressure pipeline would be required for carrying water to an existing reservoir for storage and dispersion. The estimated cost of these facilities is $35,000,000. For a pressure tunnel with an intake at Edgemoor, Delaware, the estimated cost is $45,000,000.

240. ALTERNATES CONSIDERED. Since the purpose of the proposed barrier would be to provide a source of fresh water supply, other means of providing such a supply were investigated. The two proposed reservoir projects identified as "Christiana" and "Newark", located in Delaware and discussed elsewhere in this report and included in the recommended plan, were considered as suitable alternates. In addition, other sources to augment the supplies from these reservoirs as the needs increased, were also considered. One such source is the Susquehanna River, and another is the Delaware River above the zone of salt water intrusion.

Diversion from the Susquehanna River would be at a point upstream from Conowingo Dam. The cost of providing facilities included in this scheme is estimated to be about $170,000,000 based on utilizing a pressure tunnel from the Susquehanna. Two schemes were considered wherein the Delaware above the salt water zone would be used as the source. One of these includes an intake near Poquessing Creek on the Delaware River. The facilities would cost about $200,000,000. In the other plan the intake would be at South Street in Philadelphia, and the estimated cost is about $160,000,000. Details of these alternate considerations are contained in appendix S.

241. CONCLUSIONS. The analysis made indicates that it would be physically feasible to construct, operate and maintain a barrier across the Delaware estuary and that the barrier would effectively halt the intrusion of salt water and create a fresh water pool. It was also shown that the barrier would have complex and far-reaching physical and economic effects on water-supply, navigation, flood-control, fish and wildlife, recreation and industry. Consideration of all these factors does not disclose any clear-cut justification for making additional detailed studies of the proposed barrier project at this time.

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CHAPTER XI
DISCUSSION AND CONCLUSIONS

242. **DISCUSSION**. The comprehensive review of the water resources of the Delaware River Basin was undertaken with a view to defining all current and future water control problems of the basin and formulating the most efficient and economical water control plan to satisfy these needs. Four basic considerations had an important bearing on project formulation in this study. They are: (a) the intent of Congress in authorizing the survey; (b) desires of local interests; (c) adherence to sound engineering judgment and construction principles; and (d) development of a plan of improvement which would provide the best means for achieving the balanced program with minimum investment.

243. The improvements comprising the plan of development include eleven major control projects to be developed for multiple-purposes at specified times during the next 50 years, eight major control projects to be developed initially for recreation during the next 50 years as needed, and 39 small control projects to be developed at an early date for flood control purposes under existing authorizations and continuing programs. The final survey-scope estimates of construction costs, annual costs and annual benefits for each major control project and each of the three small control projects are summarized in table XI-1. That table includes, also, preliminary benefit and cost data for the group of 36 small control projects. The projects in the plan would provide about 19 million visitor-days of recreation opportunities annually at year 2010; reduce average annual flood damages in the intermediate upstream areas about 46% and in the principal water course areas about 35 percent; meet all projected requirements for net surface water augmentations; and produce annually about 375 million kilowatt-hours of hydroelectric energy by means of conventional power plants - an additional 732 million kilowatt-hours would be produced if the pumped-storage potentiality were developed.

244. Reservoir sites that can be readily developed in the basin for the long- or short-term storage of excess surface waters are not plentiful. The major reservoir projects included in the basic plan represent the most practical and economically feasible reservoir potentials available in the basin at this time. Unless steps are taken to preserve these sites in essentially present conditions of land use, radical changes in these conditions may and probably will take place during the periods prior to the indicated construction dates. Such changes in land use may make use of the sites for reservoir purposes economically infeasible with possible far-reaching adverse effects on the economic well-being

TABLE XI-1

SUMMARY OF COSTS AND BENEFITS (EXCLUSIVE OF RECREATION TO
BE PROVIDED BY NON-FEDERAL INTERESTS AND SECOND STAGE CONSTRUCTION FOR WATER SUPPLY)
(in thousands of dollars)

(All amounts rounded; totals may not agree with sums of individual items due to rounding)

Project	Survey cost	Construction expenditures				Annual operation, maintenance, and replacement costs 1/			
	Federal	Federal	Federal costs reimbursable by non-Federal interests	Direct non-Federal costs	Total	Federal	Federal costs reimbursable by non-Federal interests	Direct non-Federal costs	Total
MAJOR CONTROL PROJECTS 3/									
Hawk Mountain	25	-	-	42,000	42,000	-	-	291	291
Prompton (Modification)	10	4,970	4,500	-	4,970	84 4/ (84) 5/	54 (38)	-	84 4/ (84) 4/
Tocks Island * (Without pumped-storage hydropower)	175	122,000	28,500	-	122,000	1,970 (1,970)	98 (20)	- -	1,970 (1,970)
Bear Creek (Modification)	15	13,400	9,110	-	13,400	120 4/ (120) 4/	64 (34)	- -	120 4/ (120) 4/
Beltzville	35	13,800	7,540	-	13,800	108 (108)	48 (34)	- -	108 (108)
Aquashicola	40	19,000	10,400	-	19,000	85 (85)	44 (34)	- -	85 (85)
Trexler	30	10,100	5,770	-	10,100	104 (104)	47 (35)	- -	104 (104)
Maiden Creek	45	27,600	17,800	-	27,600	138 (138)	55 (44)	- -	138 (138)
Blue Marsh	45	12,500	5,410	-	12,500	111 (111)	38 (26)	- -	111 (111)
Newark	20	-	-	15,300	15,300	-	-	190	190
Christiana	25	-	-	18,000	18,000	-	-	302	302
Sub-total	465	224,000	89,100	75,300	299,000	2,710 (2,710)	450 (266)	784	3,500 (2,710)
MAJOR CONTROL PROJECTS TO BE DEVELOPED IN TWO STAGES 6/									
Paulina	15	-	-	12,200	12,200	-	-	221	221
Pequest	15	-	-	4,990	4,990	-	-	115	115
Hackettstown	20	-	-	17,100	17,100	-	-	553	553
New Hampton	15	-	-	16,300	16,300	-	-	332	332
Tohickon	20	-	-	12,200	12,200	-	-	276	276
Newtown	25	-	-	27,800	27,800	-	-	415	415
French Creek	20	-	-	12,100	12,100	-	-	332	332
Evansburg	20	-	-	16,300	16,300	-	-	345	345
Sub-total	150	-	-	119,000	119,000	-	-	2,590	2,590
SMALL CONTROL PROJECTS 7/									
Parkside	2	1,000	-	21	1,020	-	-	0.3	0.3
Swiftwater	2	1,030	-	47	1,080	-	-	0.3	0.3
Jim Thorpe	2	445	-	24	469	-	-	0.3	0.3
36 small control projects listed in Table VII-1	40	6,270	-	782	7,060	-	-	11	11
Sub-total	48	8,750	-	874	9,630	-	-	12	12
TOTAL, ALL WATER CONTROL PROJECTS 3/ 6/ 7/									
Major control projects	465	224,000	89,100	75,300	299,000	2,710 (2,710)	450 (266)	784	3,500 (2,710)
Major control projects to be developed in two stages	150	-	-	119,000	119,000	-	-	2,590	2,590
Small control projects	48	8,750	-	874	9,630	-	-	12	12
Total	662	232,000	89,100	195,000	428,000	2,710 (2,710)	450 (266)	3,380	6,100 (5,310)
*Tocks Island (with non-Federal development of pumped-storage hydropower)	175	124,000	30,900 8/	53,800	177,000	1,970 (1,970)	112 (68)	3,670 (3,670)	5,630 (5,630)
*Tocks Island (with Federal development of pumped-storage hydropower)	175	177,000	24,000	-	177,000	5,630 (5,630)	86 (0)	- -	5,630 (5,630)

1/ Figures shown in parentheses are for period of deferral of use of storage for future water supply.
2/ Equivalent annual cost of survey included.
3/ Exclusive of indirectly related recreation except for Tocks Island. For details on this function see paragraph 140 and Table VII-5.
4/ Total operation,maintenance and replacement costs for multiple-purpose project.
5/ Benefits and costs for new construction expenditures.
6/ Exclusive of second stage construction for water supply after year 2010. For details see paragraph 177 and Table VII-5.
7/ Exclusive of optional recreation. For details see paragraph 187 b (2) and Table VII-5.
8/ Includes $27,300,000 for water supply and $3,600,000 joint costs allocated to pumped-storage hydropower.

TABLE XI-1

SUMMARY OF COSTS AND BENEFITS (EXCLUSIVE OF RECREATION TO
ED BY NON-FEDERAL INTERESTS AND SECOND STAGE CONSTRUCTION FOR WATER SUPPLY)
(in thousands of dollars)

s rounded; totals may not agree with sums of individual items due to rounding)

on expenditures			Annual operation, maintenance, and replacement costs 1/				Total annual economic costs 2/	Total annual project benefits	Benefit-cost ratio
Federal costs imbursable non-Federal interests	Direct non-Federal costs	Total	Federal	Federal costs reimbursable by non-Federal interests	Direct non-Federal costs	Total			
MAJOR CONTROL PROJECTS 3/									
-	42,000	42,000	-	-	291	291	2,760	3,220	1.2
4,500	-	4,970	84 4/ (84) 4/	54 (38)	-	84 4/ (84) 4/	349 5/	486 5/	1.4
8,500	-	122,000	1,970 (1,970)	98 (20)	- -	1,970 (1,970)	7,700	17,100	2.2
9,110	-	13,400	120 4/ (120) 4/	64 (34)	- -	120 4/ (120) 4/	714 5/	1,880 5/	2.6
7,540	-	13,800	108 (108)	48 (34)	- -	108 (108)	683	1,130	1.7
0,400	-	19,000	85 (85)	44 (34)	- -	85 (85)	876	936	1.1
5,770	-	10,100	104 (104)	47 (35)	- -	104 (104)	553	858	1.6
7,800	-	27,600	138 (138)	55 (44)	- -	138 (138)	1,390	1,490	1.1
5,410	-	12,500	111 (111)	38 (26)	- -	111 (111)	643	1,050	1.6
-	15,300	15,300	-	-	190	190	998	1,670	1.7
-	18,000	18,000	-	-	302	302	1,260	2,370	1.9
9,100	75,300	299,000	2,710 (2,710)	450 (266)	784	3,500 (2,710)	17,900	32,200	1.8
MAJOR CONTROL PROJECTS TO BE DEVELOPED IN TWO STAGES 6/									
-	12,200	12,200	-	-	221	221	767	960	1.3
-	4,990	4,990	-	-	115	115	350	499	1.4
-	17,100	17,100	-	-	553	553	1,420	2,400	1.7
-	16,300	16,300	-	-	332	332	1,040	1,440	1.4
-	12,200	12,200	-	-	276	276	899	1,200	1.3
-	27,800	27,800	-	-	415	415	1,970	1,800	0.9
-	12,100	12,100	-	-	332	332	877	1,440	1.6
-	16,300	16,300	-	-	345	345	1,170	1,500	1.3
-	119,000	119,000	-	-	2,590	2,590	8,490	11,200	1.3
SMALL CONTROL PROJECTS 7/									
-	21	1,020	-	-	0.3	0.3	37	42	1.1
-	47	1,080	-	-	0.3	0.3	39	71	1.8
-	24	469	-	-	0.3	0.3	17	18	1.03
-	782	7,060	-	-	11	11	267	457	1.7
-	874	9,630	-	-	12	12	361	587	1.6
TOTAL, ALL WATER CONTROL PROJECTS 3/ 6/ 7/									
9,100	75,300	299,000	2,710 (2,710)	450 (266)	784	3,500 (2,710)	17,900	32,200	1.8
-	119,000	119,000	-	-	2,590	2,590	8,490	11,200	1.3
-	874	9,630	-	-	12	12	361	587	1.6
9,100	195,000	428,000	2,710 (2,710)	450 (266)	3,380	6,100 (5,310)	26,800	44,000	1.6
0,900 8/	53,800	177,000	1,970 (1,970)	112 (68)	3,670 (3,670)	5,630 (5,630)	18,100	28,100	1.6
4,000	-	177,000	5,630 (5,630)	86 (0)	- -	5,630 (5,630)	16,400	28,100	1.7

l of use of storage for future water supply.

Tocks Island. For details on this function see paragraph 140 and Table VII-5.
multiple-purpose project.

y after year 2010. For details see paragraph 177 and Table VII-5.
graph 187 b (2) and Table VII-5.
joint costs allocated to pumped-storage hydropower.

of the water service area. The intial development of eight major control projects for recreation has the added advantages of site preservation inherent in the two-stage development. For the major control projects proposed for multiple-purpose development at indicated dates during the next 50 years, a program to acquire the reservoir lands at an early date is in order.

245. Proposed Federal and non-Federal participation in the development of the individual projects is in accordance with general policies expressed in the Flood Control Act of 1936, Section 4 of the Flood Control Act of 1944, and the Water Supply Act of 1958. However, the apportionment of recreation and pumped-storage power costs at the Tocks Island Project are worthy of note. Studies showed that the recreation benefits at the Tocks Island Project will have widespread regional and national significance and, accordingly, all specific and allocated recreation costs were assigned generally to Federal interests. The physical features in the vicinity of the Tocks Island dam site are uniquely suited to the development of pumped-storage facilities at this location. Analysis of the prospective peak electric power load for the foreseeable future in the region that facilities at Tocks Island would supply shows that an increasing demand for peak power will exist. A large block of peak power at Tocks Island therefore will be marketable if it can be produced economically. Analyses of incremental benefits and costs attributable to the facility show that the project would probably be feasible as either a Federal or a non-Federal venture. However, the margin is insufficient to justify a conclusion that the facility should be constructed as a Federal venture, as it has not been practicable to establish definitely either the cost of the off-peak energy required for pumping or the marketing price of the peak energy to be produced by the facility. Although private power interests have furnished written evidence of their willingness to develop these facilities at non-Federal expense, there is no compelling reason to conclude at this time that development should be accomplished as a non-Federal project. The approximate range of Federal and non-Federal participation in the plan of development is summarized in tables XI-2 and XI-3. A definite and equitable allocation would involve detailed consideration of numerous and complex factors which can best be developed by detailed study prior to construction.

246. Additional information on recommended projects called for in Senate Resolution 148, 85th Congress, 1st Session, adopted 28 January 1958, is contained in Attachment A to this report.

247. At the time of preparation of this report, firm information on the monetary value of the benefits and damages that would be reflected upon fish and wildlife resources, by virtue of the development of the projects in the proposed plan of development, was not available from the Fish and Wildlife Service for use in economic analyses. In its reconnaissance report, appendix J, however, the Service states that in order to mitigate the effects of the 19 major control projects on present stream fisheries in privately-owned areas to be affected by the

projects, the acquisition in public ownership and improvement of 18 miles of stream would be required. Similarly, the Service finds that the acquisition in public ownership and improvement of 46,796 acres of land would be required to maintain the "status quo" for public

projects, the acquisition in public ownership and improvement of 18 miles of stream would be required. Similarly, the Service finds that the acquisition in public ownership and improvement of 46,796 acres of land would be required to maintain the "status quo" for public

TABLE XI-2
ANALYSIS OF FEDERAL AND NON-FEDERAL CONSTRUCTION COSTS
(FOR PLAN PRESENTED IN TABLE XI-1)
(All amounts rounded; totals may not agree with sums of individual items due to rounding)
(in thousands of dollars)

Project	Distribution of Construction Costs between Project Functions 1/									Apportionments			
	Flood Control		Recreation		Power		Water Supply						
	Federal	Direct non-Federal	Federal	Direct non-Federal	Federal	Direct non-Federal	Federal	Federal Costs Reimbursable by non-Federal interests	Direct non-Federal	Federal	Federal Costs Reimbursable by non-Fed. interests	Direct non-Fed.	Tota
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14
MAJOR CONTROL PROJECTS 2/													
Hawk Mountain	-	-	-	1,580	-	8,150	-	-	32,300	-		42,000	42,0
Prompton (Modification)	-218 3/	-	681	-	-	-	4,500	4,500 (90.7)	-	4,970	4,500 (90.7)	-	4,9
Tocks Island* (without pumped-storage hydropower)	14,200	-	58,200	-	21,500	-	28,500	28,500 (23.3)	-	122,000	28,500 (23.3)	-	122,0
Bear Creek (Modification)	3,510 4/	-	824	-	-	-	9,110	9,110 (67.8)	-	13,400	9,110 (67.8)	-	13,
Beltzville	4,720	-	1,560	-	-	-	7,540	7,540 (54.6)	-	13,800	7,540 (54.6)	-	13,
Aquashicola	6,490	-	2,050	-	-	-	10,400	10,400 (55.0)	-	19,000	10,400 (55.0)	-	19,
Trexler	2,150	-	2,150	-	-	-	5,770	5,770 (57.3)	-	10,100	5,770 (57.3)	-	10,
Maiden Creek	5,610	-	4,140	-	-	-	17,800	17,800 (64.7)	-	27,600	17,800 (64.7)	-	27,
Blue Marsh	5,140	-	1,950	-	-	-	5,410	5,410 (43.2)	-	12,500	5,410 (43.2)	-	12,
Newark	-	-	-	5,430	-	-	-	-	9,830	-	-	15,300	15,
Christiana	-	-	-	7,780	-	-	-	-	10,300	-	-	18,000	18,
Sub-Total	41,600	-	71,500	14,800	21,500	8,150	89,100	89,100	52,400	224,000	89,100	75,300	299,
MAJOR CONTROL PROJECTS TO BE DEVELOPED IN TWO STAGES 5/													
[illegible]	-	-	-	12,200 6/	-	-	-	-	-	-	-	12,200	12,
[illegible]	-	-	-	4,990 6/	-	-	-	-	-	-	-	4,990	4,9
[illegible]	-	-	-	17,100 6/	-	-	-	-	-	-	-	17,100	17,
[illegible]	-	-	-	16,300 6/	-	-	-	-	-	-	-	16,300	16,
[illegible]	-	-	-	12,200 6/	-	-	-	-	-	-	-	12,200	12,
[illegible]	-	-	-	27,800 6/	-	-	-	-	-	-	-	27,800	27,
[illegible]	-	-	-	12,100 6/	-	-	-	-	-	-	-	12,100	12,
[illegible]	-	-	-	16,300 6/	-	-	-	-	-	-	-	16,300	16,
[illegible]	-	-	-	119,000 6/	-	-	-	-	-	-	-	119,000	119,0
SMALL CONTROL PROJECTS 7/													
[illegible]	1,000	21	-	-	-	-	-	-	-	1,000	-	21 (2.0) 8/	1,0
[illegible]	1,030	47	-	-	-	-	-	-	-	1,030	-	47 (4.4) 8/	1,0
[illegible]	445	24	-	-	-	-	-	-	-	445	-	24 (5.2) 8/	4
[illegible] small control projects listed in Table VII-5	6,270	782	-	-	-	-	-	-	-	6,270	-	782 (11.1) 8/	7,0
Sub-Total	8,750	874	-	-	-	-	-	-	-	8,750	-	874	9,6
TOTAL, ALL WATER CONTROL PROJECTS 2/ 5/ 7/													
Major control projects	41,600	-	71,500	14,800	21,500	8,150	89,100	89,100	52,400	224,000	89,100	75,300	299,
Major control projects to be developed in two stages	-	-	-	119,000 6/	-	-	-	-	-	-	-	119,000	119,
Small control projects	8,750	874	-	-	-	-	-	-	-	8,750	-	874	9,
Total	50,400	874	71,500	134,000	21,500	8,150	89,100	89,100	52,400	232,000	89,100	195,000	428,
*Tocks Island (with non-Federal development of pumped-storage hydropower)	13,800	-	57,300	-	21,500	53,800 3,600 9/	27,300	27,300 (22.1)	-	124,000	30,900 (25.0)	53,800	177,
*Tocks Island (with Federal development of pumped-storage hydropower)	12,100	-	56,400	-	84,700	-	24,000	24,000 (13.6)	-	177,000	24,000 (13.6)	-	177,

1/ Figures in parentheses express reimbursable costs as percentages of Federal construction costs.
2/ Exclusive of indirectly related recreation except for Tocks Island. For details on this function see paragraph 140 and Table VII-5.
3/ Net credit to existing project.
4/ Net allocation to flood control function of existing project.
5/ Exclusive of second stage construction for water supply after year 2010. For details see paragraph 177 and Table VII-5.
6/ Includes cost of acquisition of site for future water supply construction.
7/ Exclusive of optional recreation. For details see paragraph 187b(2) and Table VII-5. The three projects exceeding $400,000 in cost are listed separately.
8/ Percentages of total project cost.
9/ Joint cost allocated to pumped-storage hydropower; Federal cost reimbursable by non-Federal interests.

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TABLE XI-3
ANALYSIS OF FEDERAL AND NON-FEDERAL ANNUAL OPERATION, MAINTENANCE AND REPLACEMENT COSTS
(FOR PLAN PRESENTED IN TABLE XI-1)
(All amounts rounded; totals may not agree with sums of individual items due to rounding.)
(in thousands of dollars)

Project	Distribution of Annual Operation, Maintenance and Replacement Costs Among Project Functions 1/									APPORTIONMENTS			Total
	FLOOD CONTROL		RECREATION		POWER		WATER SUPPLY						
	Federal	Direct non-Fed.	Federal	Direct non-Fed.	Federal	Direct non-Fed.	Federal	Federal costs reimbursable by non-Fed. interests	Direct non-Fed.	Federal	Federal costs reimbursable by non-Fed. interests	Direct non-Fed.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
MAJOR CONTROL PROJECTS 2/													
Hawk Mountain	-	-	-	44	-	151	-	-	97	-	-	291	291
Prompton (Modification)	10	-	19	-	-	-	54	54 (65.2)	-	84	54 (65.2)	-	84
3/	23	-	22	-	-	-	38	38 (45.8)	-	84	38 (45.8)	-	84
Tocks Island*(without pumped-storage hydro-power)	58	-	1,550	-	257	-	98	98 (9.9) 4/	-	1,970	98 (9.9) 4/	-	1,970
3/	75	-	1,590	-	284	-	20	20 (2.0) 4/	-	1,970	20 (2.0) 4/	-	1,970
Bear Creek (Modification)	31	-	25	-	-	-	64	64 (53.7)	-	120	64 (53.7)	-	120
3/	58	-	27	-	-	-	34	34 (28.7)	-	120	34 (28.7)	-	120
Beltzville	30	-	29	-	-	-	48	48 (44.8)	-	108	48 (44.8)	-	108
3/	41	-	33	-	-	-	34	34 (31.7)	-	108	34 (31.7)	-	108
Aquashicola	28	-	13	-	-	-	44	44 (52.5)	-	85	44 (52.5)	-	85
3/	36	-	15	-	-	-	34	34 (39.7)	-	85	34 (39.7)	-	85
Trexler	18	-	40	-	-	-	47	47 (45.2)	-	104	47 (45.2)	-	104
3/	23	-	46	-	-	-	35	35 (33.9)	-	104	35 (33.9)	-	104
Maiden Creek	17	-	66	-	-	-	55	55 (39.6)	-	138	55 (39.6)	-	138
3/	23	-	70	-	-	-	44	44 (32.1)	-	138	44 (32.1)	-	138
Blue Marsh	36	-	36	-	-	-	38	38 (34.7)	-	111	38 (34.7	-	111
3/	45	-	39	-	-	-	26	26 (23.6)	-	111	26 (23.6)	-	111
Newark	-	-	-	127	-	-	-	-	63	-	-	190	190
Christiana	-	-	-	241	-	-	-	-	61	-	-	302	302
Sub-Total	227	-	1,780	412	257	151	450	450	221	2,710	450	784	3,500
3/	325	-	1,840	-	284	-	266	266	-	2,710	266	-	2,710
MAJOR CONTROL PROJECTS TO BE DEVELOPED IN TWO STAGES 5/													
Paulina	-	-	-	221	-	-	-	-	-	-	-	221	221
Pequest	-	-	-	115	-	-	-	-	-	-	-	115	115
Hackettstown	-	-	-	553	-	-	-	-	-	-	-	553	553
New Hampt	-	-	-	332	-	-	-	-	-	-	-	332	332
Tohickon	-	-	-	276	-	-	-	-	-	-	-	276	276
Newtown	-	-	-	415	-	-	-	-	-	-	-	415	415
[illegible]	-	-	-	332	-	-	-	-	-	-	-	332	332

Evansburg	-	-	-	345	-	-	-	-	-	-	-	345	345
Sub-Total	-	-	-	2,590	-	-	-	-	-	-	-	2,590	2,590
SMALL CONTROL PROJECTS 6/													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	(32.1)	[illegible]	[illegible]	(32.1)	0.3	[illegible]
Blue Marsh	**36**	**-**	**36**	**-**	**-**	**-**	**38**	**38 (34.7)**	**-**	**111**	**38 (34.7**	**-**	**111**
3/	45	-	39	-	-	-	26	26 (23.6)	-	111	26 (23.6)	-	111
Newark	-	-	-	127	-	-	-	-	63	-	-	190	190
Christiana	-	-	-	241	-	-	-	-	61	-	-	302	302
Sub-Total	227	-	1,780	412	257	151	450	450	221	2,710	450	784	3,500
3/	325	-	1,840	-	284	-	266	266	-	2,710	266	-	2,710
MAJOR CONTROL PROJECTS TO BE DEVELOPED IN TWO STAGES 5/													
Paulina	-	-	-	221	-	-	-	-	-	-	-	221	221
Pequest	-	-	-	115	-	-	-	-	-	-	-	115	115
Hackettstown	-	-	-	553	-	-	-	-	-	-	-	553	553
New Hampton	-	-	-	332	-	-	-	-	-	-	-	332	332
Tohickon	-	-	-	276	-	-	-	-	-	-	-	276	276
Newtown	-	-	-	415	-	-	-	-	-	-	-	415	415
French Creek	-	-	-	332	-	-	-	-	-	-	-	332	332
Evansburg	-	-	-	345	-	-	-	-	-	-	-	345	345
Sub-Total	-	-	-	2,590	-	-	-	-	-	-	-	2,590	2,590
SMALL CONTROL PROJECTS 6/													
Parkside	-	0.3	-	-	-	-	-	-	-	-	-	0.3	-
Swiftwater	-	0.3	-	-	-	-	-	-	-	-	-	0.3	-
Jim Thorpe	-	0.3	-	-	-	-	-	-	-	-	-	0.3	-
36 small projects projects listed in Table VII-1	-	11	-	-	-	-	-	-	-	-	-	11	11
Sub-Total	-	12	-	-	-	-	-	-	-	-	-	12	12
TOTAL, ALL WATER CONTROL PROJECTS 2/ 5/ 6/													
Major control projects	227	-	1,780	412	257	151	450	450	221	2,710	450	784	3,500
3/	325	-	1,840	-	284	-	266	266	-	2,710	266	-	2,710
Major control projects to be developed in two stages	-	-	-	2,590	-	-	-	-	-	-	-	2,590	2,590
Small control projects	-	12	-	-	-	-	-	-	-	-	-	12	12
Total	227	12	1,780	3,000	257	151	450	450	221	2,710	450	3,380	6,100
3/	325	NA	1,840	NA	284	NA	266	266	NA	2,710	266	NA	5,310
*Tocks Island (with non-Federal development of pumped-storage hydro-power)	52	-	1,550	-	254	3,670 26 7/	86	86 (1.8) 4/	-	1,970	112 (2.4) 4/	3,670	5,630
3/	62	-	1,570	-	270	3,670 68 7/	-	- (0)	-	1,970	68 (1.4) 4/	3,670	5,630
*Tocks Island (with Federal development of pumped-storage hydropower)	52	-	1,550	-	3,950	-	86	86 (1.8) 4/	-	5,630	86 (1.8) 4/	-	5,630
3/	60	-	1,570	-	4,010	-	-	- (0)	-	5,630	- (0)	-	5,630

[illegible] in parentheses express reimbursable costs as percentages of total OM&R costs.
[illegible] of indirectly related recreation except for Tocks Island.
[illegible] costs during period of deferred use of future water supplies.
[illegible] is based on the development without indirectly related recreation.
5/ Exclusive of second stage construction for water supply after year 2010.
6/ Exclusive of optional recreation.
7/ Joint cost allocated to pumped-storage hydropower; Federal cost reimbursable by non-Federal interests.
NA Not applicable

2

AD-A043 791 ARMY ENGINEER DISTRICT PHILADELPHIA PA F/G 8/6
REPORT ON THE COMPREHENSIVE SURVEY OF THE WATER RESOURCES OF TH--ETC(U)
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hunting and game habitat now in areas to be affected by the projects. Other measures proposed by the Service include access, sanitary, parking and boat launching facilities at each project, arrangements for water releases of prescribed volume and temperatures for downstream fisheries, and fishery management operations for reservoirs. An interim report on late investigations by the Fish and Wildlife Service indicates that the plan of development described for each project in chapter VII would largely mitigate and compensate for the above indicated damages to fish and wildlife resources. In considering this latest view of the Service, it is believed that the overall conclusions of this report will not be materially affected by the insertion of the Service's monetary evaluations when they become available. An addendum to appendix J is being prepared by the Fish and Wildlife Service, and it is understood that the addendum will give firm monetary evaluations for fish and wildlife benefits and damages due to the projects. The addendum, when received, could be added to the appendix and the report modified, if necessary, during the review process.

248. Federal agencies, States and principal municipalities, responsible for the functions and activities embraced in the plan, were informed, as the study progressed, of the features of the comprehensive plan. At the conclusion of the studies four public hearings were held at points in the basin to advise local interests of the findings of the study and to afford them opportunities to express their views. It is believed that interests in the basin are in general agreement with the plan presented. Under the review procedures prescribed for this survey report local interests will be afforded opportunity for further comment.

249. CONCLUSIONS. The control and utilization of the stream flows of the basin to alleviate flood damages; provide supplies of water for municipal, industrial and rural uses; provide recreation opportunities; generate hydroelectric energy; and provide the products of related land and water management are required to sustain the economic well-being of the Delaware River Basin and its water service area. It is concluded from studies of impounding measures, local protection works, a salt water barrier and other practical alternative measures that the most feasible and economic way to satisfy these requirements is the development of the plan of control projects discussed above. It is concluded also that these requirements can be further satisfied by supplemental programs to provide land management measures, control use of the flood plains, remove pollution loads, and conserve ground and surface waters.

250. The benefits to be realized from the development of the proposed plan for the control and utilization of the water

resources will exceed the cost of such development. The nature and widespread effects of benefits from the plan of development warrant Federal participation in the costs of development to the extent indicated in the discussion.

CHAPTER XII

RECOMMENDATIONS

251. The District Engineer recommends:

a. That the plan as formulated in this report and consisting of the following elements be adopted as the Comprehensive Plan for development and beneficial public use of the water resources of the Delaware River Basin:

(1) Construction of the projects as listed, and for the purposes shown, in table VII-5 at a total estimated cost of $591,000,000 of which $143,000,000 would be Federal cost and $89,100,000 would be Federal cost reimbursable by non-Federal interests.

(2) Continuous and vigorous action by Federal and non-Federal agencies, separately and cooperatively under authorities that exist or may be provided, in prosecution of programs for land management, controlling and regulating the use and development of flood plains, preservation and development of recreation and fish and wildlife resources, abatement of stream pollution and improvement of water quality, conservation of ground and surface waters, and preservation of sites for the projects that comprise the Comprehensive Plan.

b. That the units of the Comprehensive Plan designated as Beltzville, Blue Marsh, Trexler, Tocks Island (without the pumped-storage power feature), Aquashicola, Maiden Creek, and modification of the existing Prompton and Bear Creek projects be authorized for construction at a presently estimated total Federal cost of $134,900,000 plus $89,100,000 reimbursable by non-Federal interests for water supply storage, making a total of $224,000,000, and a presently estimated annual maintenance, operation and replacement cost of $2,710,000, of which $266,000 is for water supply storage and reimbursable by non-Federal interests before use of storage for future water supply is begun and of which $450,000 is reimbursable by non-Federal interests after use of storage for future water supply is initiated, all in accordance with plans contained in this report and as summarized in tables XI-2 and XI-3; that immediately following authorization detailed site investigations and designs be made for these projects in an orderly and expeditious program for the purpose of accurately defining the project lands required; and that subsequently advance acquisition be made of such title to such lands as may be required to preserve the sites against incompatible development, all subject to such modifications as in the discretion of the Chief of Engineers may be advisable and subject also to the following provisions with respect to these projects:

(1) That the non-Federal share of first cost and operation and maintenance costs for each project be determined by the percentages shown in columns 9 and 12 in tables XI-2 and XI-3 applied to actual costs for the completed project.

(2) That before construction of each individual project non-Federal interests contribute all lands and costs assigned to non-Federal interests, arrange for repayment of water supply storage in a manner conforming to applicable laws and satisfactory to the Secretary of the Army, and agree to bear the assigned percentage of annual operation and maintenance costs as summarized in columns 9 and 12 of table XI-3.

(3) That the timing and sequence established in this report for construction of the projects may be altered when in the judgment of the Chief of Engineers such change is desirable.

(4) That construction of individual projects recommended for authorization will not construe a committment on the part of the Federal Government nor the responsible non-Federal interests for construction of the remaining projects.

(5) That non-Federal interests agree to undertake establishment and prosecution of programs for acquisition of lands and to develop facilities as needed for the recreation developments assigned to them.

T. H. SETLIFFE
Colonel, CE
District Engineer

DELETIONS

Tables XII-1, XII-2, XII-3 and XII-4 previously appearing on Pages 173 thru 176 have been deleted.

ACKNOWLEDGEMENTS AND IDENTIFICATION OF PERSONNEL

1. This report was prepared by the Valley Report Group, a special unit established in the District organization to conduct the Delaware River Basin Survey. This group was directly responsible to the District Engineer. The report is based on studies and investigations made by the Corps of Engineers and other agencies listed in the appendices.

2. The preparation of this report was under the general supervision and direction of:

Colonel T. H. Setliffe, CE, District Engineer
(July 1959 - present)

and his predecessors:

Colonel Allen F. Clark, Jr. (Jan. 1955 - Nov. 1957)
(now Brigadier General, retired)

Colonel W. F. Powers (retired) (Dec. 1957 - Mar. 1959)

Lt. Colonel Frank A. Gehrig, Jr. (Apr. 1959 - June 1959)

3. This report was prepared and written under the direct staff supervision of:

Russell Morgan, Chief, Valley Report Group

Principal assistants were:

V. V. Lisovitch, Asst. Chief, Valley Report Group
D. E. Donley, Chief, Plans & Report Unit
M. R. Iakisch, Chief, Hydrology & Hydraulics Unit
C. C. McNamara, Chief, Design & Estimate Unit
S. A. Chestnut, Chief, Publications & Graphics Unit
Lester G. Duck, Recreation Studies
Robert M. Gidez, Economist
Clarence V. Pierce, Geologist

4. District consultants were:

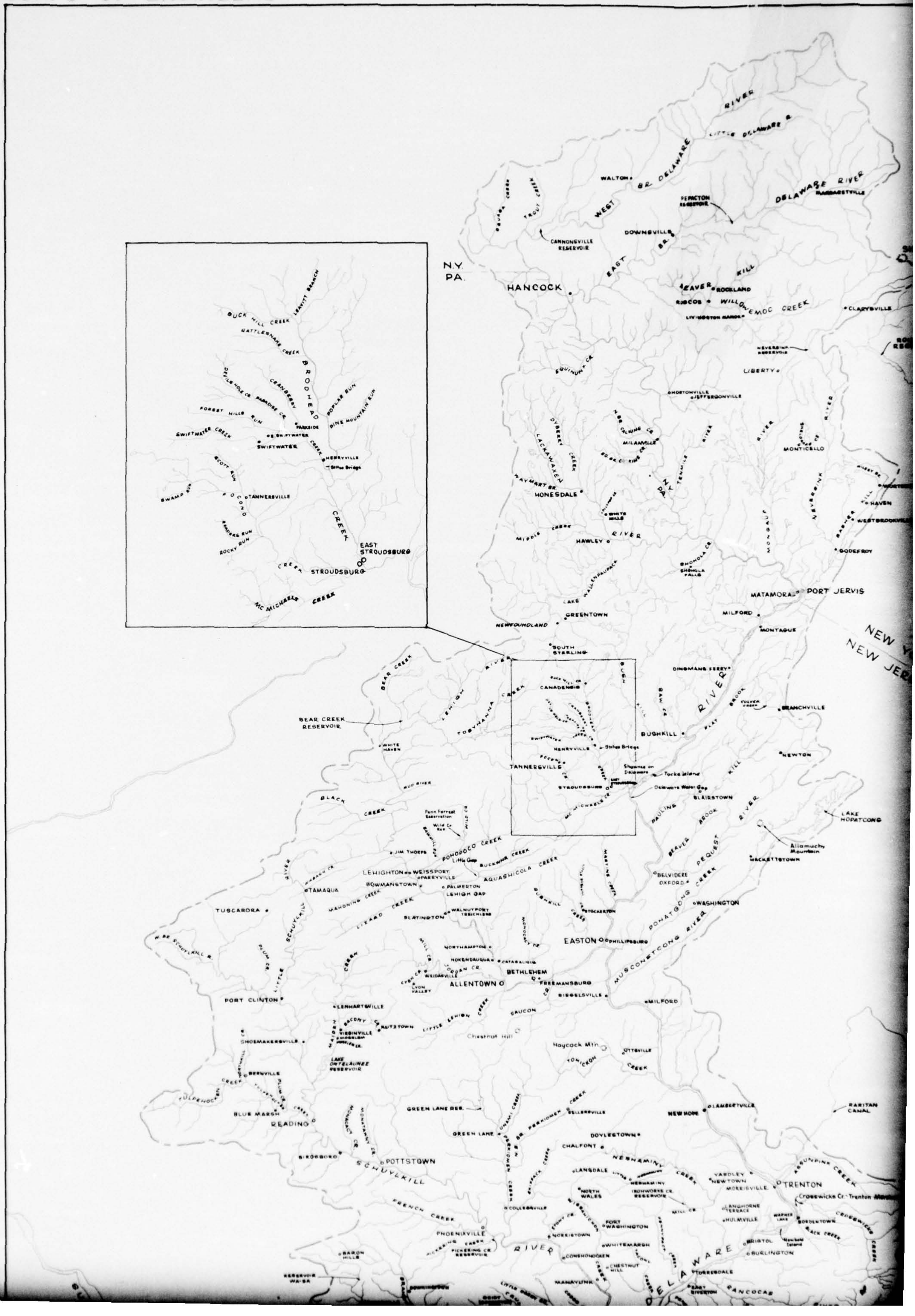
Arthur A. Klein, Engineering Division
Design and Estimates

Leslie W. Piel, Real Estate Division
Real Estate Studies

5. The District Engineer, Philadelphia, acknowledges with appreciation the cooperation and assistance rendered in connection with this report by personnel of a number of other offices and agencies, states, municipalities and industries, particularly the following:

Army Engineer District, Baltimore
Army Engineer District, Norfolk
Army Engineer Division, North Atlantic
City of New York Board of Water Supply
City of Philadelphia Water Department
Commonwealth of Pennsylvania
Delaware River Basin Advisory Committee
Department of Agriculture
Department of Commerce
Department of the Interior
Federal Power Commission
Interstate Commission on the Delaware River Basin
Public Health Service
State of Delaware
State of New Jersey
State of New York

CORPS OF ENGINEERS



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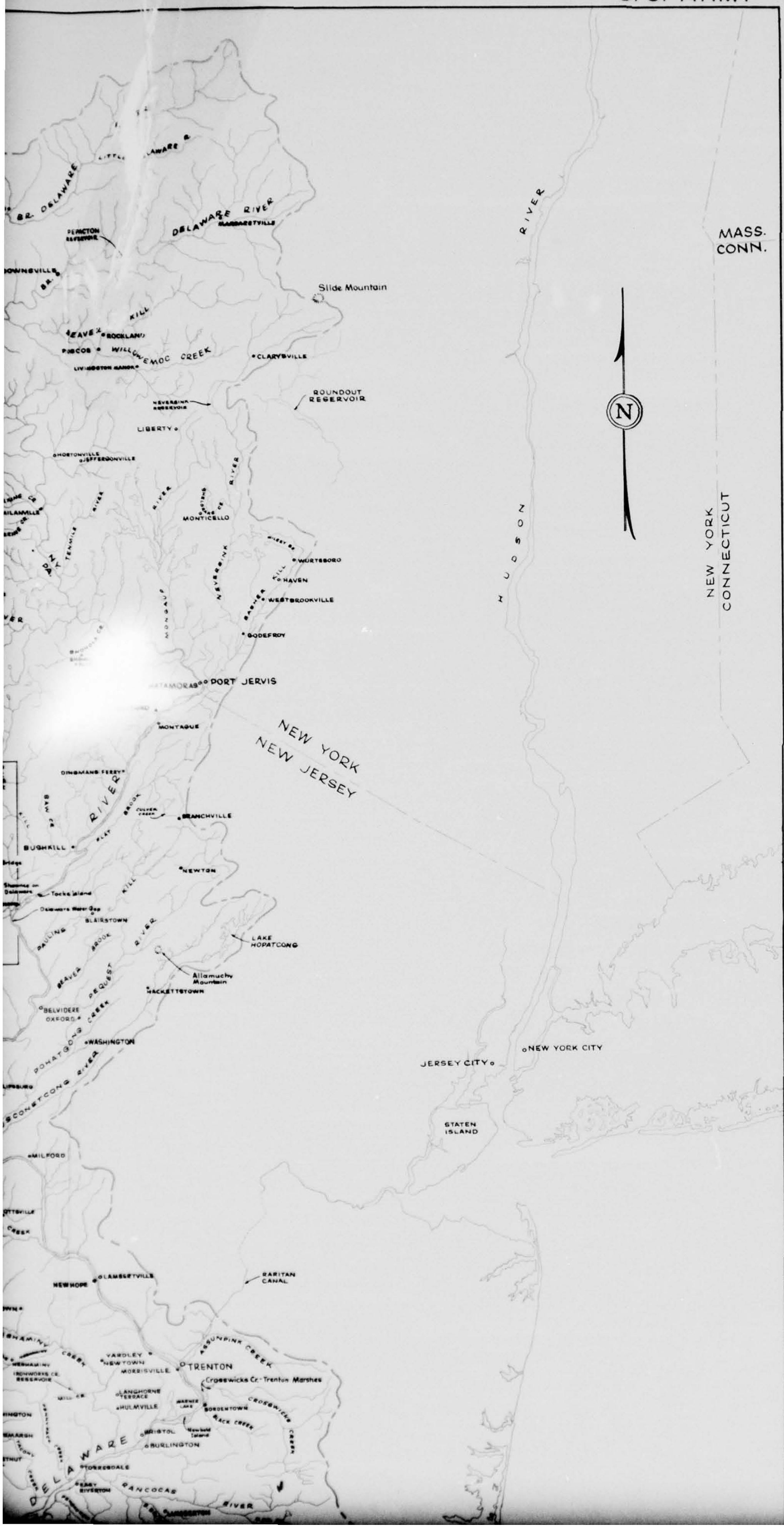
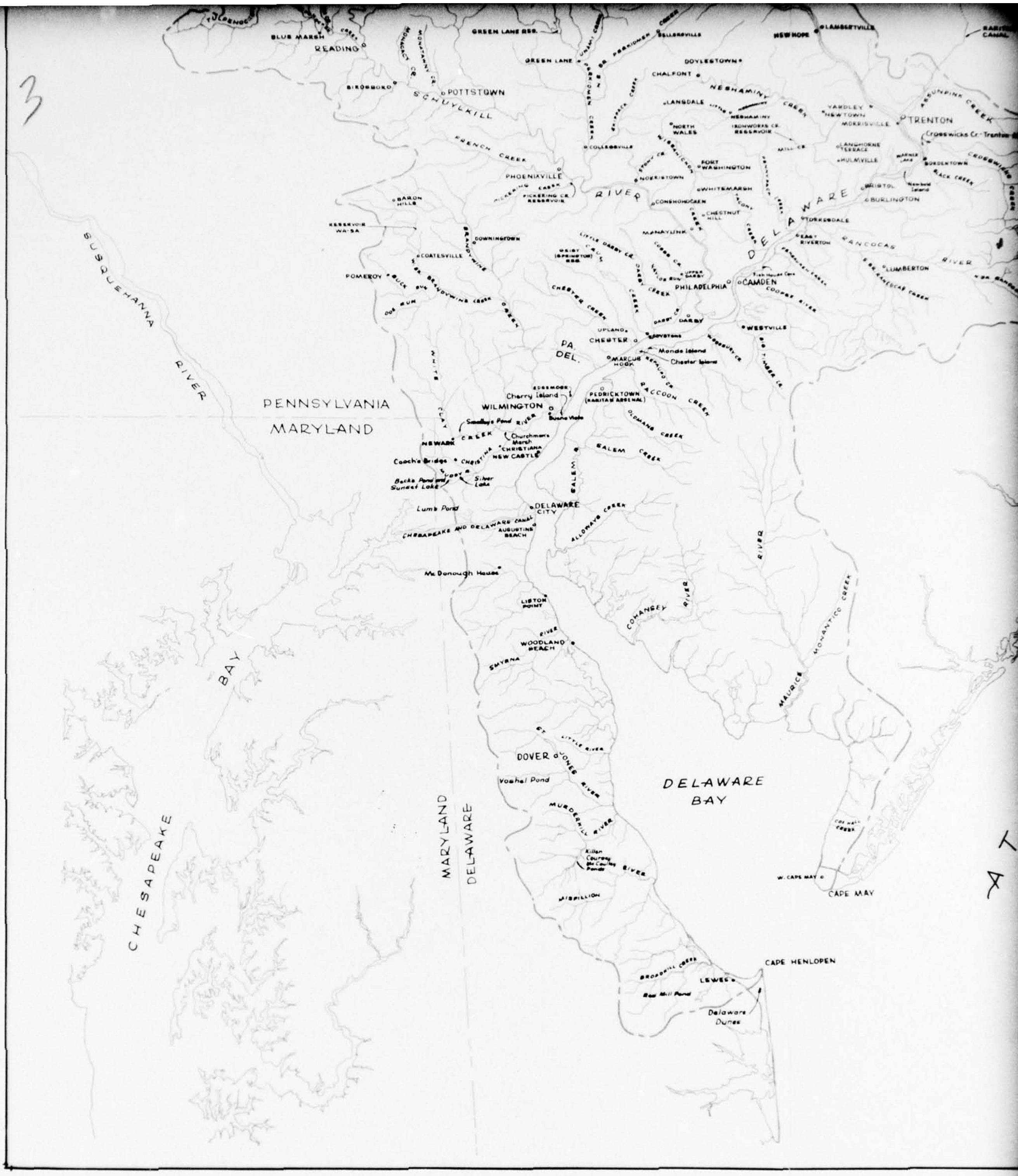
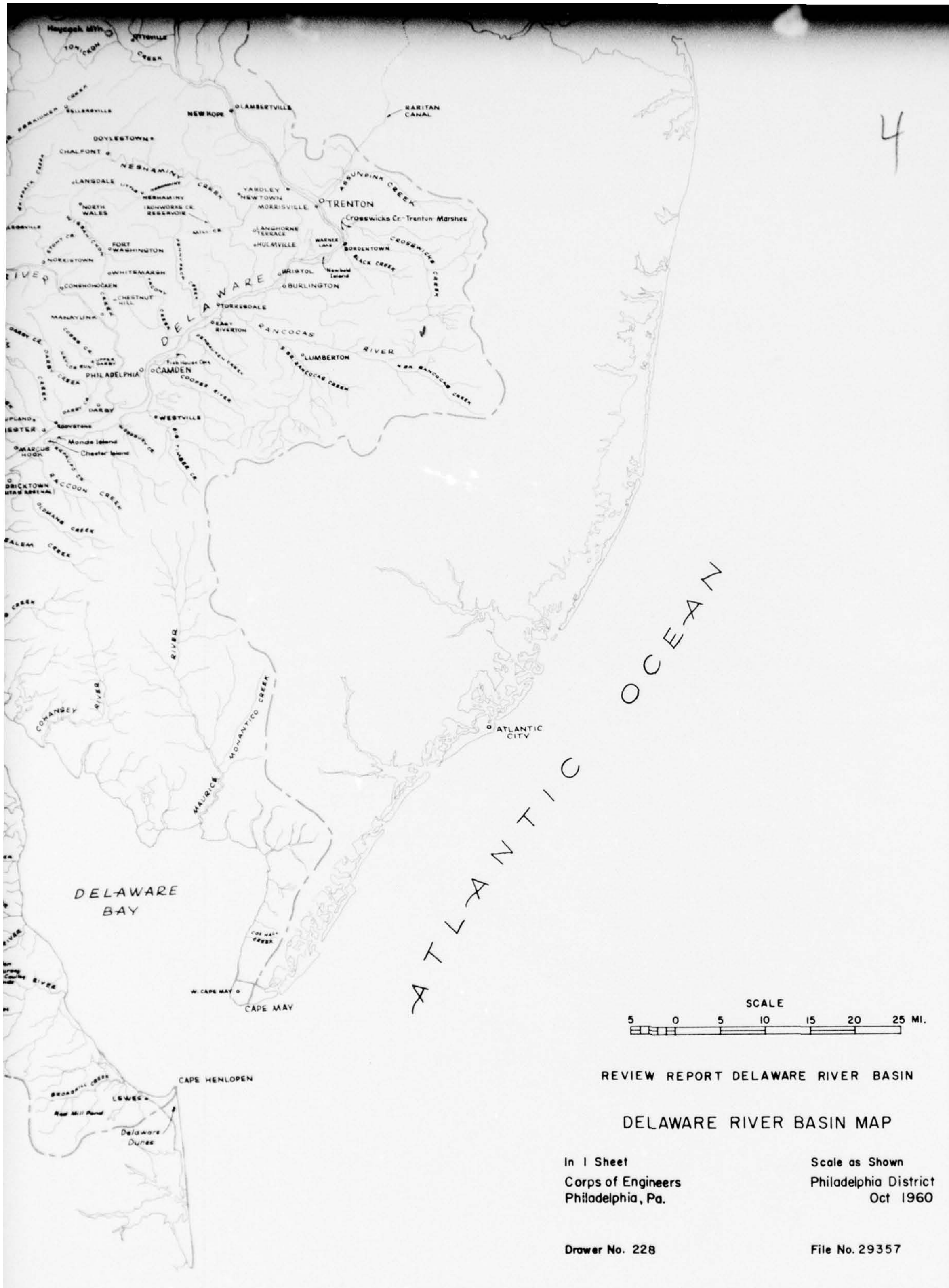


DELAWARE RIVER
MARGARETVILLE
Slide Mountain
WILLOWEMOC CREEK
CLARYSVILLE
ROUNDOUT RESERVOIR
LIBERTY
MONTICELLO
WURTSBORO
WESTBROOKVILLE
GODEFROY
PORT JERVIS
MONTAGUE
NEW YORK
NEW JERSEY
BRANCHVILLE
BUSHKILL
NEWTON
BLAIRSTOWN
LAKE HOPATCONG
Allamuchy Mountain
HACKETTSTOWN
BELVIDERE
OXFORD
WASHINGTON
MILFORD
NEW HOPE
RARITAN CANAL
TRENTON
Crosswicks Cr.-Trenton Marshes
YARDLEY
NEWTOWN
MORRISVILLE
BORDENTOWN
BRISTOL
BURLINGTON
DELAWARE
RANCOCAS
RIVER
HUDSON
RIVER
N
MASS.
CONN.
NEW YORK
CONNECTICUT
JERSEY CITY
NEW YORK CITY
STATEN ISLAND


3
BLUE MARSH
READING
GREEN LANE RES.
GREEN LANE
NEW HOPE
LAMBERTVILLE
DOYLESTOWN
CHALFONT
NESHAMINY CREEK
LANSDALE
NORTH WALES
POTTSTOWN
SCHUYLKILL
BIRDSBORO
FRENCH CREEK
PHOENIXVILLE
COLLEGEVILLE
NORRISTOWN
FORT WASHINGTON
WHITEMARSH
CONSHOHOCKEN
CHESTNUT HILL
MANAYUNK
RIVER
YARDLEY
NEWTOWN
MORRISVILLE
TRENTON
ASSUNPINK CREEK
LANGHORNE TERRACE
HULMEVILLE
BORDENTOWN
BRISTOL
BURLINGTON
DELAWARE
TORRESDALE
RIVERTON
RANCOCAS
LUMBERTON
RIVER
CROSSWICKS CREEK
BARON HILLS
RESERVOIR WA-SA
DOWNINGTOWN
COATESVILLE
POMEROY
BRANDYWINE CREEK
SUSQUEHANNA RIVER
PHILADELPHIA
CAMDEN
COOPER RIVER
DARBY
WESTVILLE
UPLAND
CHESTER
MARCUS HOOK
Monds Island
Chester Island
PA.
DEL.
PENNSYLVANIA
MARYLAND
WILMINGTON
Cherry Island
PEDRICKTOWN
RACCOON CREEK
OLDMANS CREEK
NEWARK
Churchmans Marsh
CHRISTIANA
NEW CASTLE
Cooch's Bridge
Silver Lake
Becks Pond and Sunset Lake
SALEM CREEK
SALEM
Lums Pond
DELAWARE CITY
CHESAPEAKE AND DELAWARE CANAL
AUGUSTINE BEACH
ALLOWAYS CREEK
McDonough House
LISTON POINT
COHANSEY RIVER
RIVER
SMYRNA RIVER
WOODLAND BEACH
MAURICE
MANANTICO CREEK
CHESAPEAKE
BAY
DOVER
LITTLE RIVER
JONES RIVER
Voshel Pond
DELAWARE
BAY
MARYLAND
DELAWARE
MURDERKILL RIVER
Killen Pond
MISPILLION RIVER
W. CAPE MAY
CAPE MAY
AT
CAPE HENLOPEN
BROADKILL CREEK
LEWES
Red Mill Pond
Delaware Dunes

4



REVIEW REPORT DELAWARE RIVER BASIN

DELAWARE RIVER BASIN MAP

In 1 Sheet
Scale as Shown

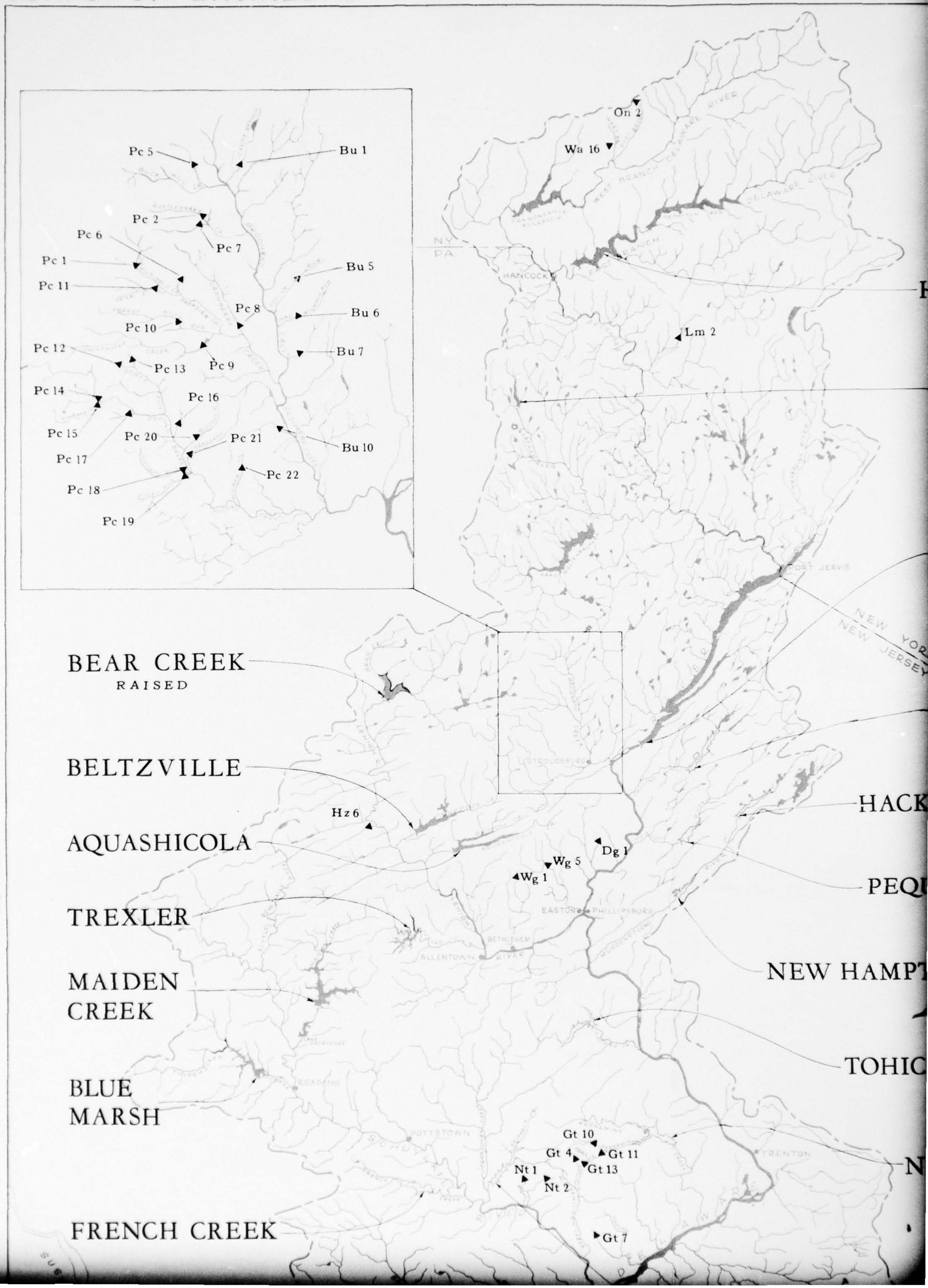
Corps of Engineers
Philadelphia, Pa.

Philadelphia District
Oct 1960

Drawer No. 228
File No. 29357

PLATE 1

CORPS OF ENGINEERS



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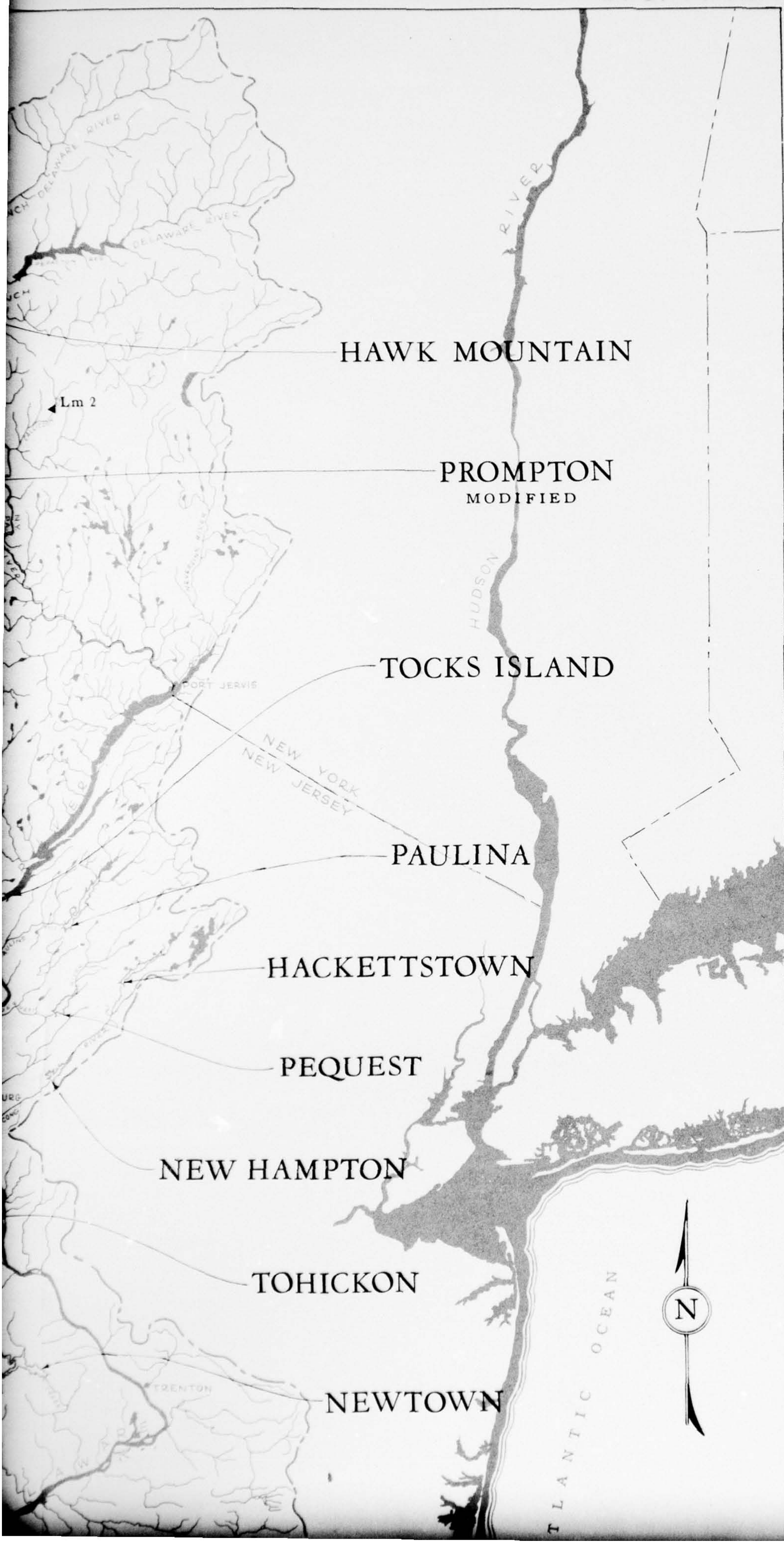
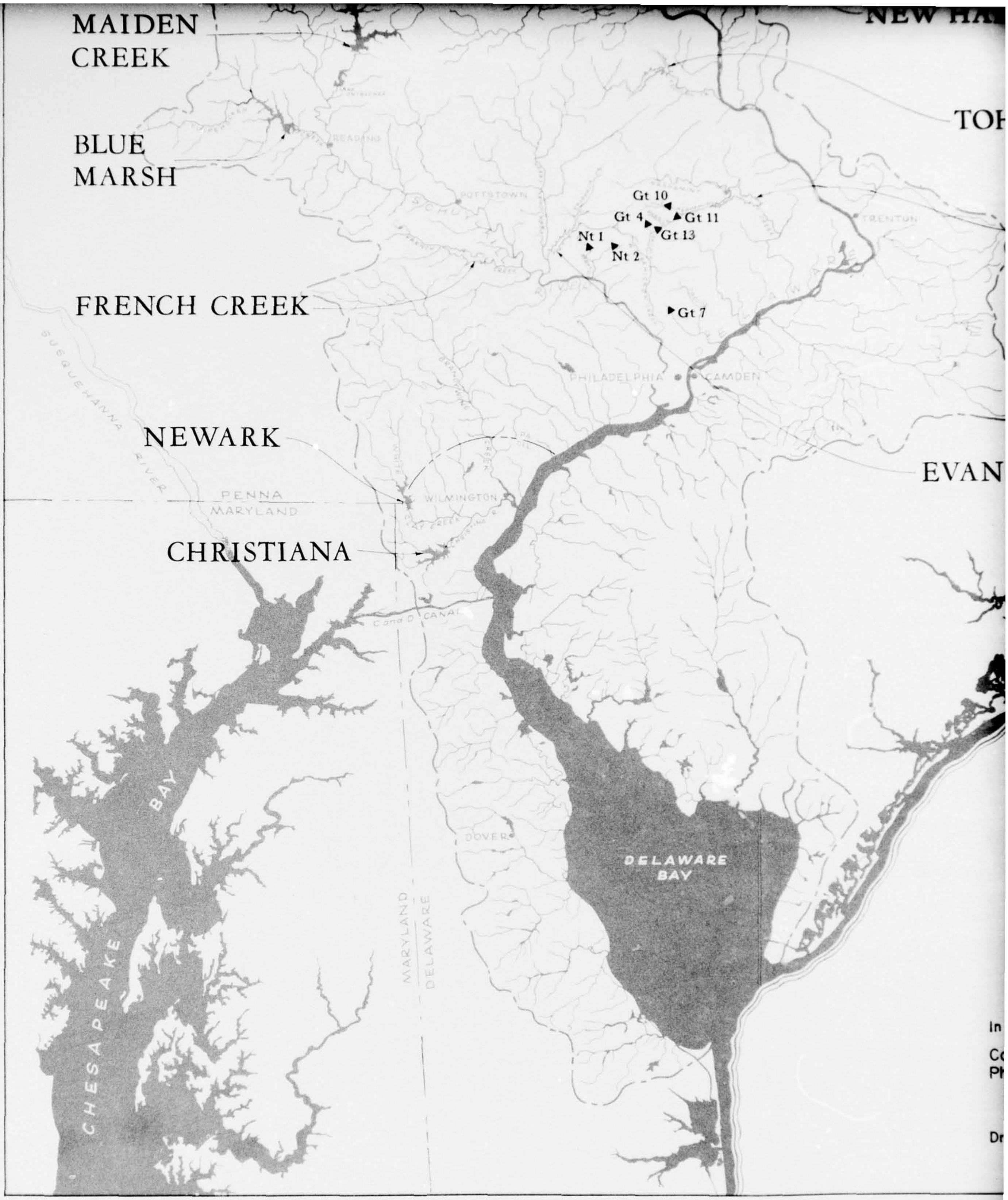
U.S. ARMY

2



HAWK MOUNTAIN
Lm 2
PROMPTON
MODIFIED
TOCKS ISLAND
PAULINA
HACKETTSTOWN
PEQUEST
NEW HAMPTON
TOHICKON
NEWTOWN
DELAWARE RIVER
HUDSON
RIVER
PORT JERVIS
NEW YORK
NEW JERSEY
TRENTON
TLANTIC OCEAN
N

3



MAIDEN CREEK
BLUE MARSH
FRENCH CREEK
NEWARK
CHRISTIANA
READING
POTTSTOWN
TRENTON
Gt 10
Gt 4
Gt 11
Gt 13
Nt 1
Nt 2
Gt 7
PHILADELPHIA
CAMDEN
SUSQUEHANNA RIVER
PENNA
MARYLAND
WILMINGTON
C and D CANAL
DOVER
DELAWARE BAY
CHESAPEAKE BAY
MARYLAND
DELAWARE

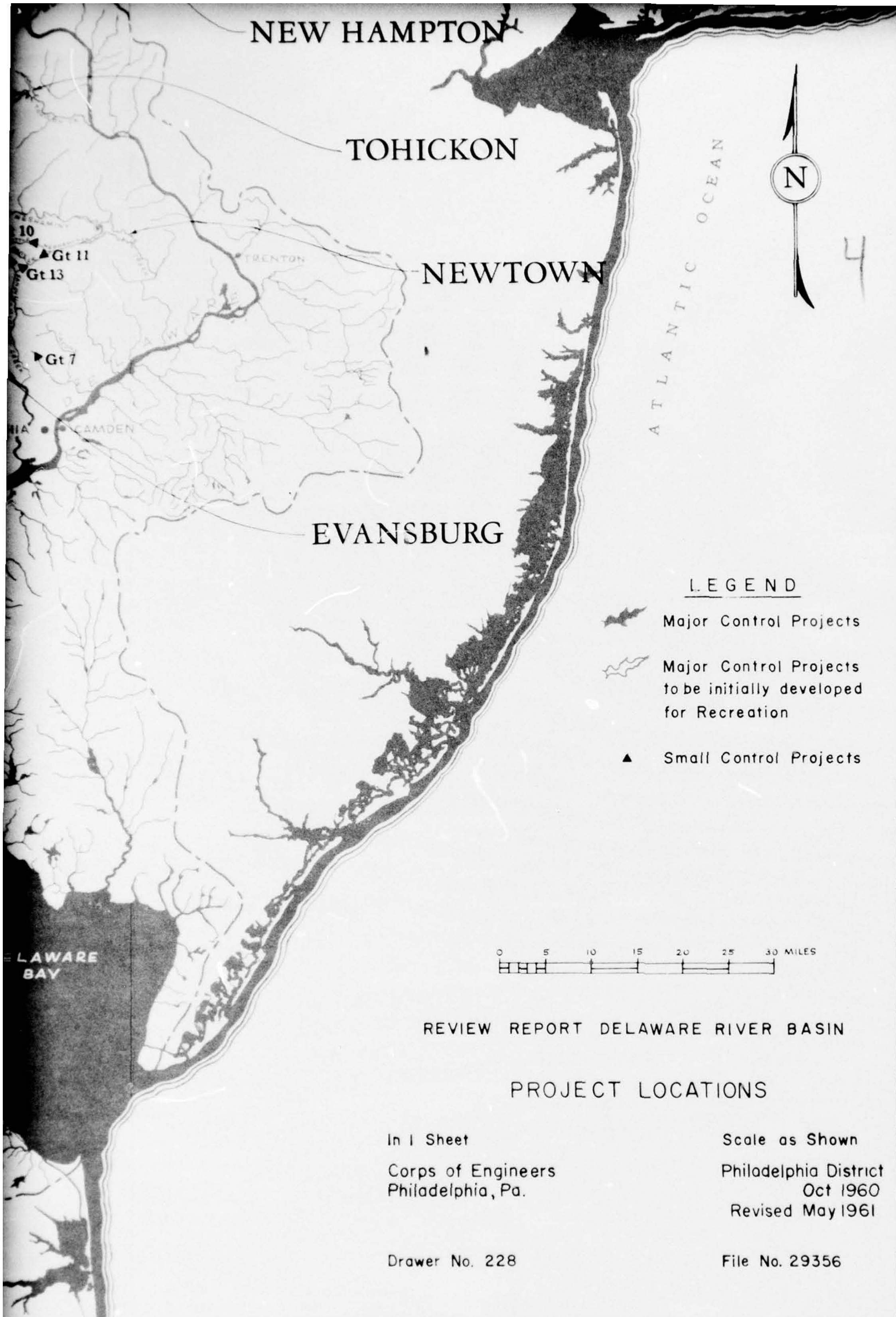


PLATE 9
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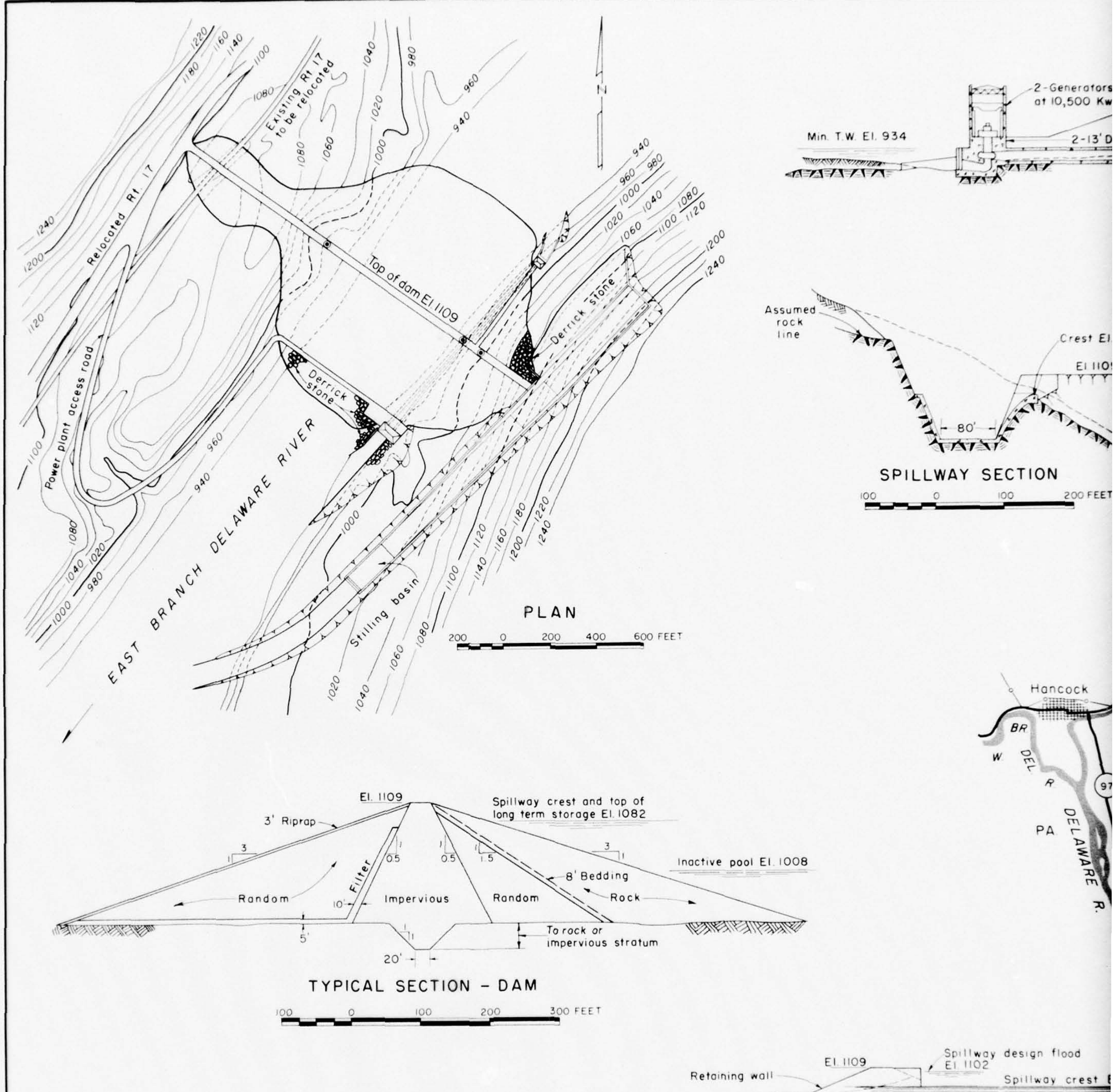
CORPS OF ENGINEERS



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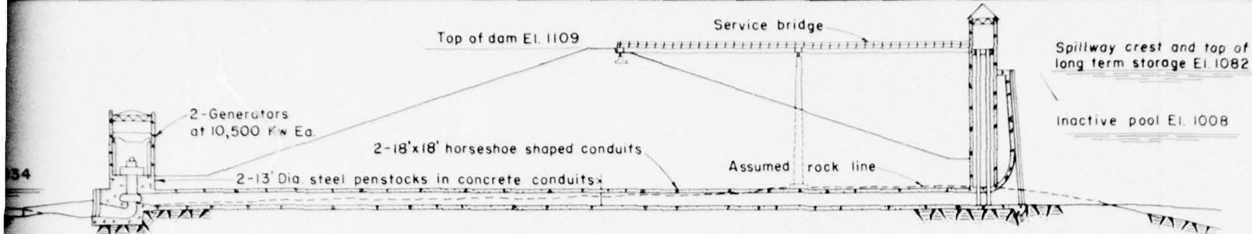
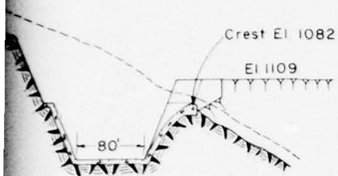


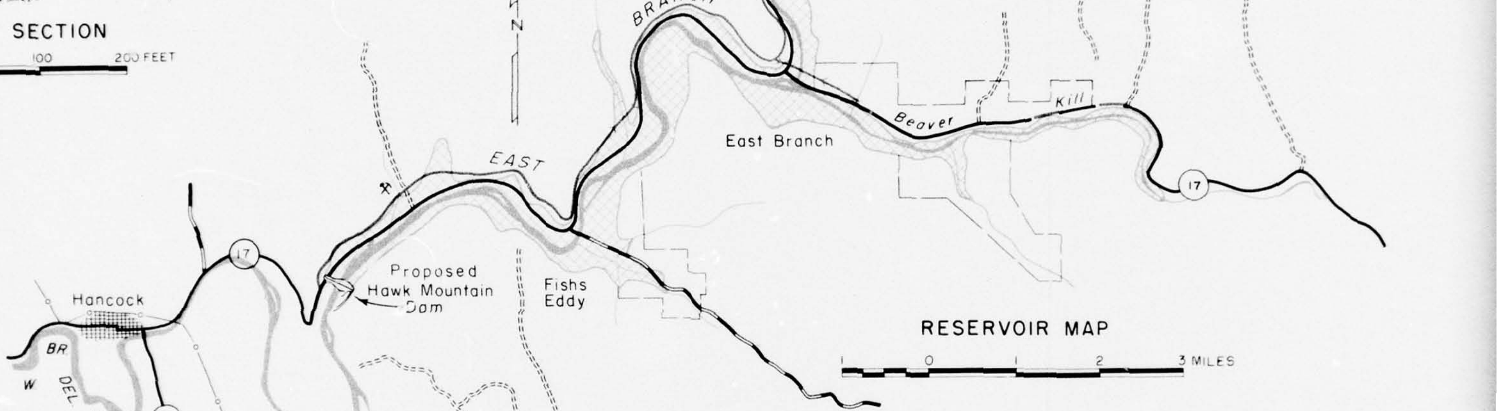
SECTION - OUTLET WORKS

100 0 100 200 300 FEET



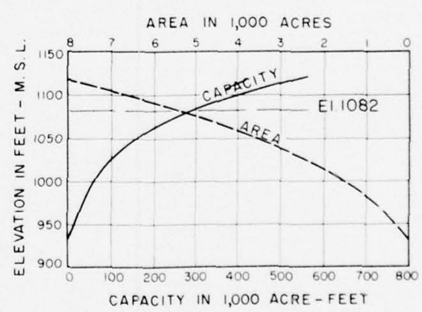
SPILLWAY SECTION

0 100 200 FEET



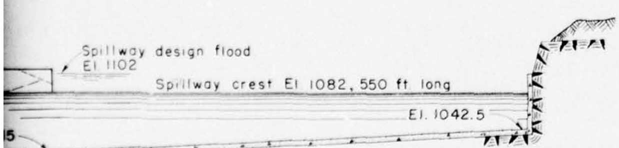
RESERVOIR MAP

1 0 1 2 3 MILES



RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Minimum Pool	1,008	60,000	1,500
Spillway Level	1,082	293,000	5,400



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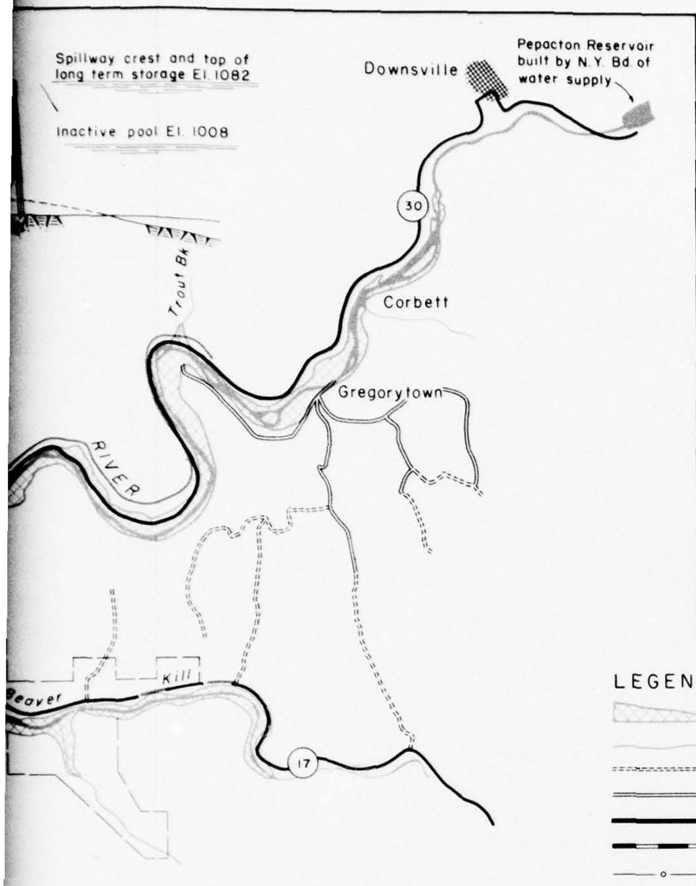
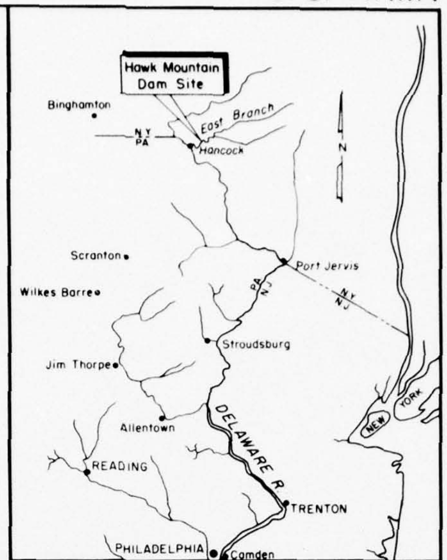


RESERVOIR MAP

0 1 2 3 MILES



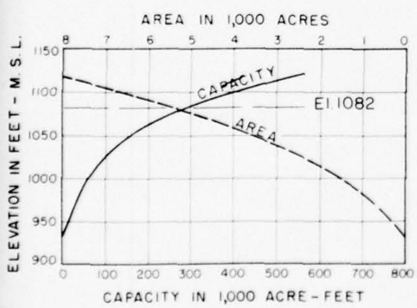
LOCATION MAP

SCALE

5 0 5 10 15 20 25 MI

LEGEND

- Long Term Storage El. 1082
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Petroleum Line
- Proposed Relocated Hard Surface Heavy Duty Road
- Land Acquisition for Recreation Development
- Drill Hole
- Quarry



RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Minimum Pool	1,008	60,000	1,500
Spillway Level	1,082	293,000	5,400

REVIEW REPORT DELAWARE RIVER BASIN

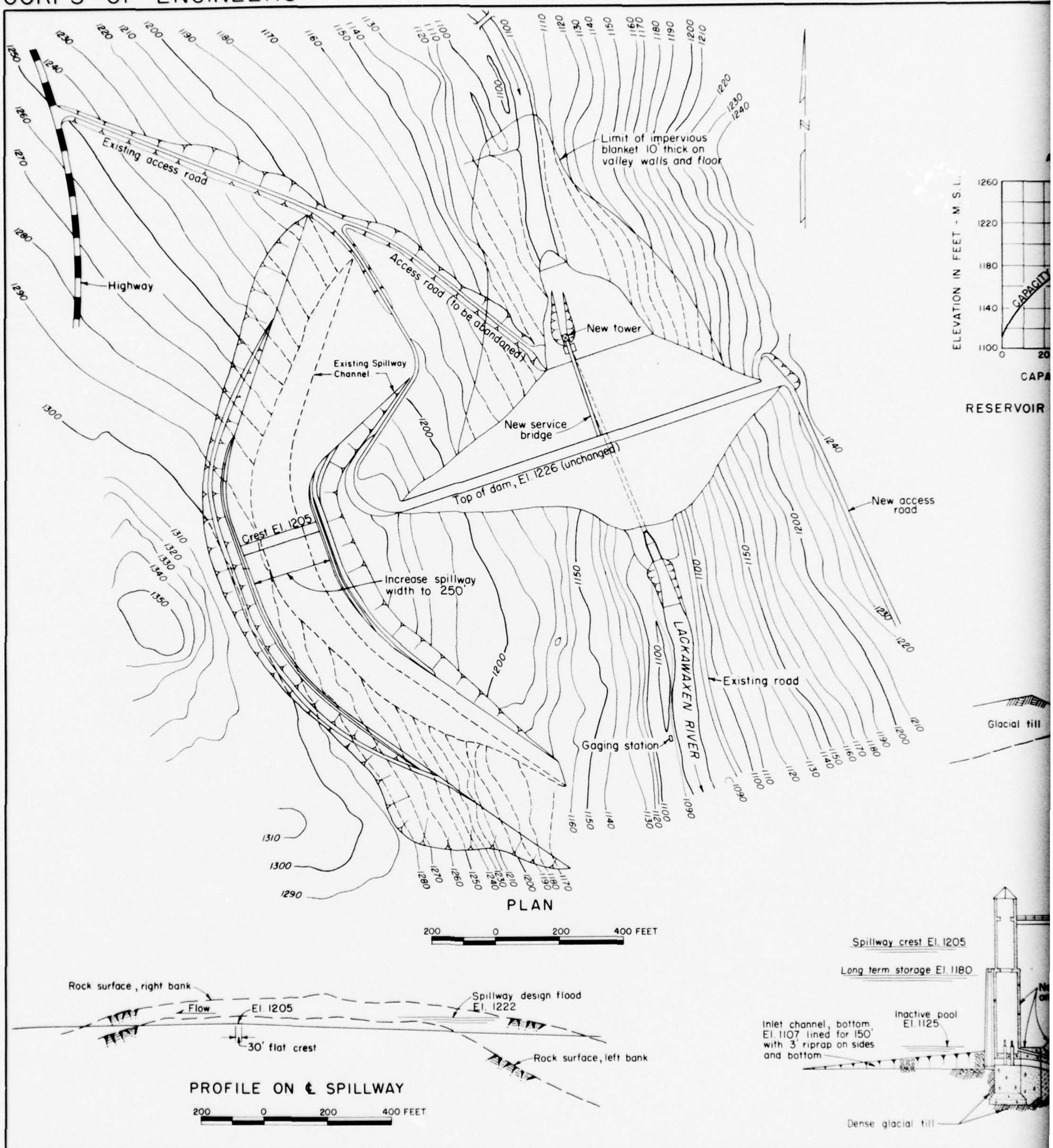
HAWK MOUNTAIN PROJECT

In 1 Sheet — Scale as Shown

Corps of Engineers, Philadelphia, Pa. — Philadelphia District, June 1960

Drawer No. 228 — File No. 29124

CORPS OF ENGINEERS



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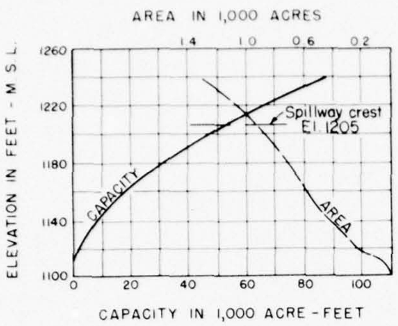
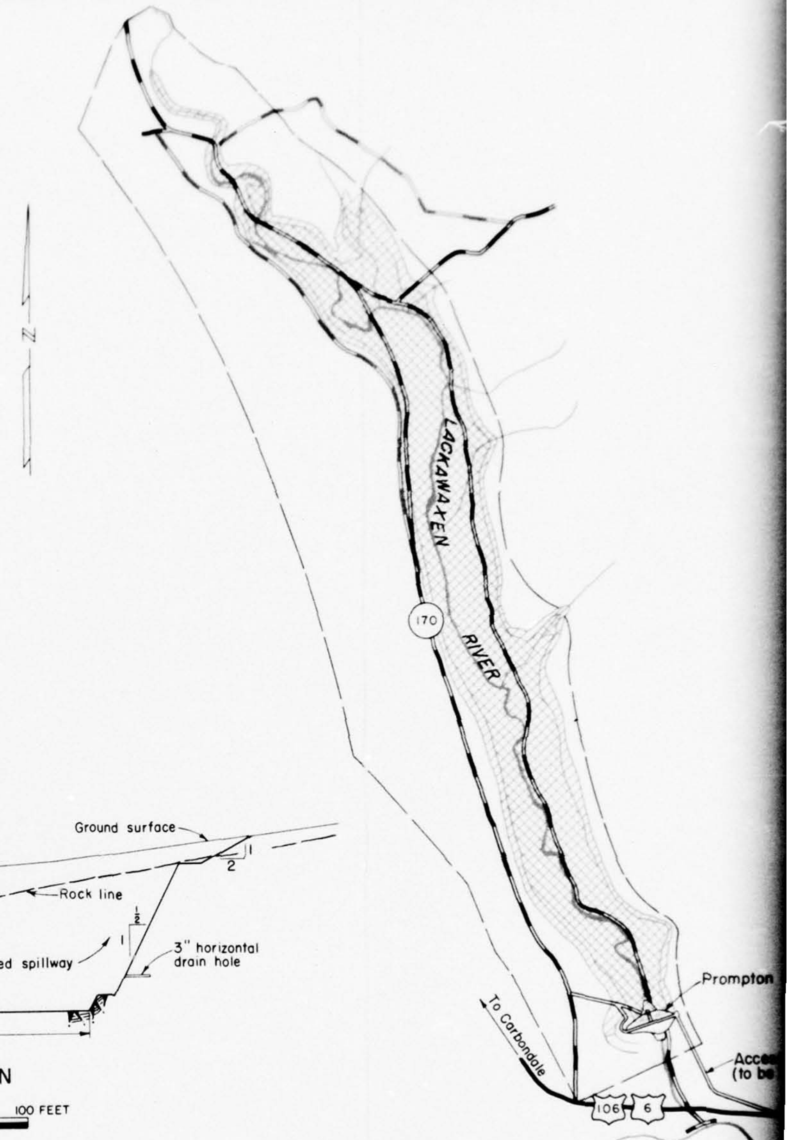
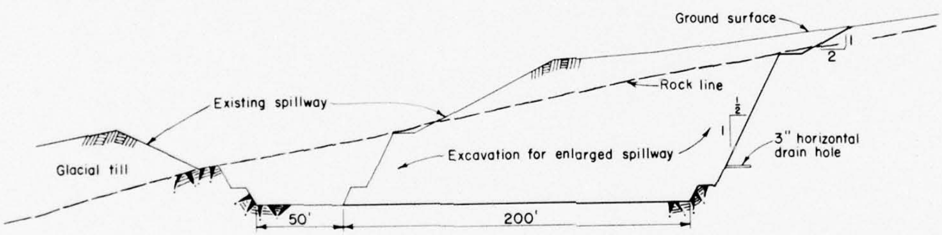


RESERVOIR AREA AND CAPACITY CURVES



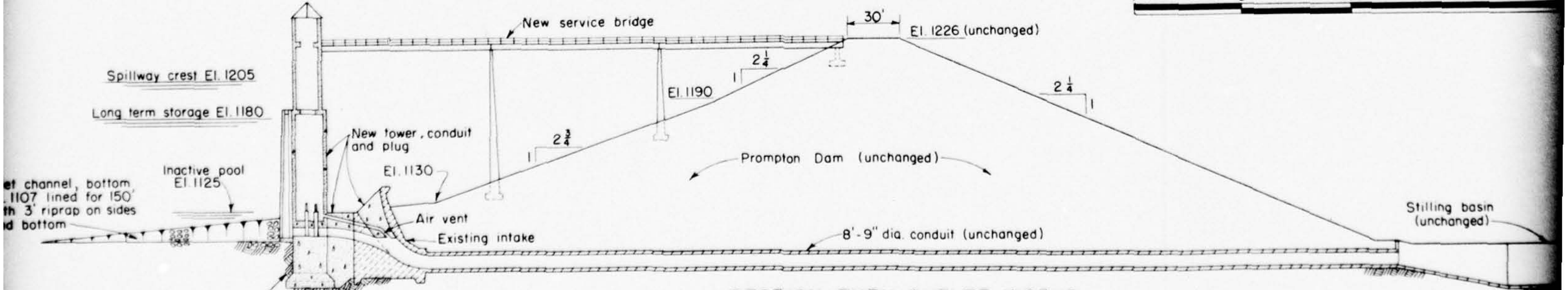


SPILLWAY SECTION
(Facing downstream)

50 0 50 100 FEET

RESERVOIR MAP

1 1/2 0

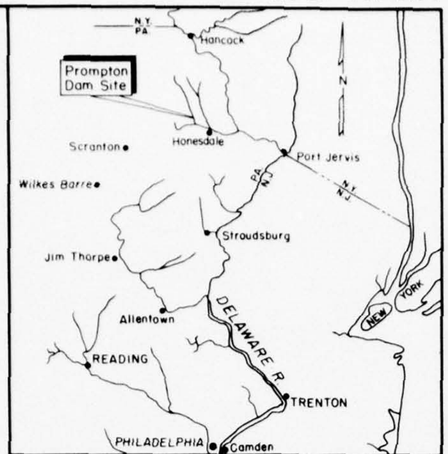


SECTION THRU OUTLET WORKS

50 0 50 100 FEET

3

U.S. ARMY



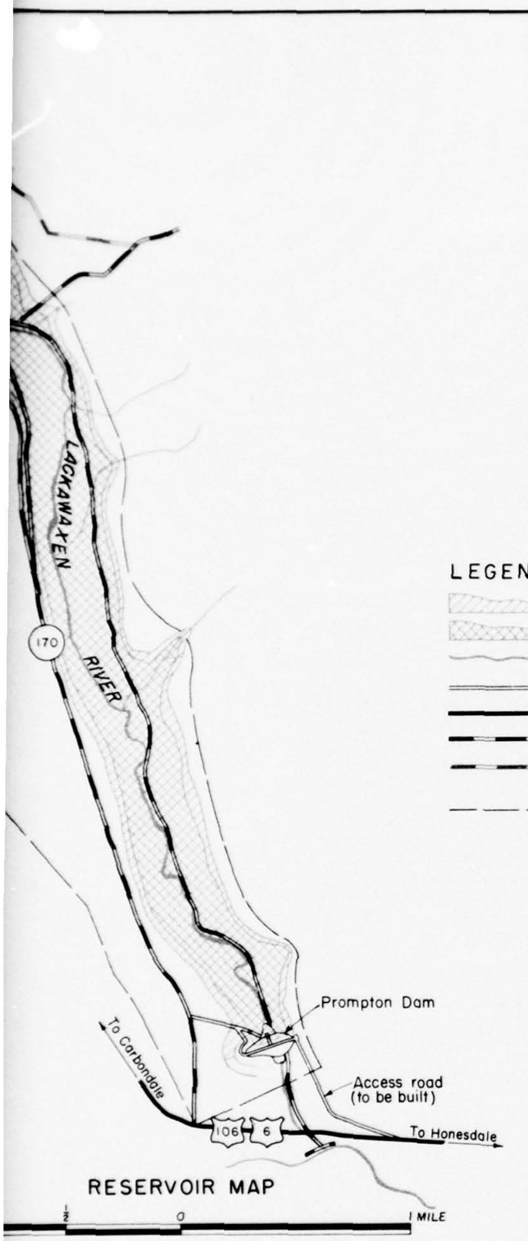
LOCATION MAP

SCALE

5 0 5 10 15 20 25 MI.

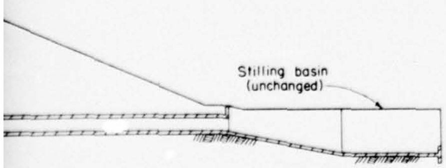
LEGEND

- Reservoir at El. 1205
- Long Term Storage El. 1180
- Existing Stream
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Proposed Relocated Secondary Hard Surface Road
- Land Acqisition for Recreation Development



RESERVOIR MAP

½ 0 1 MILE



REVIEW REPORT DELAWARE RIVER BASIN

PROMPTON PROJECT, MODIFIED

In 1 Sheet

Scale as Shown

Corps of Engineers
Philadelphia, Pa.

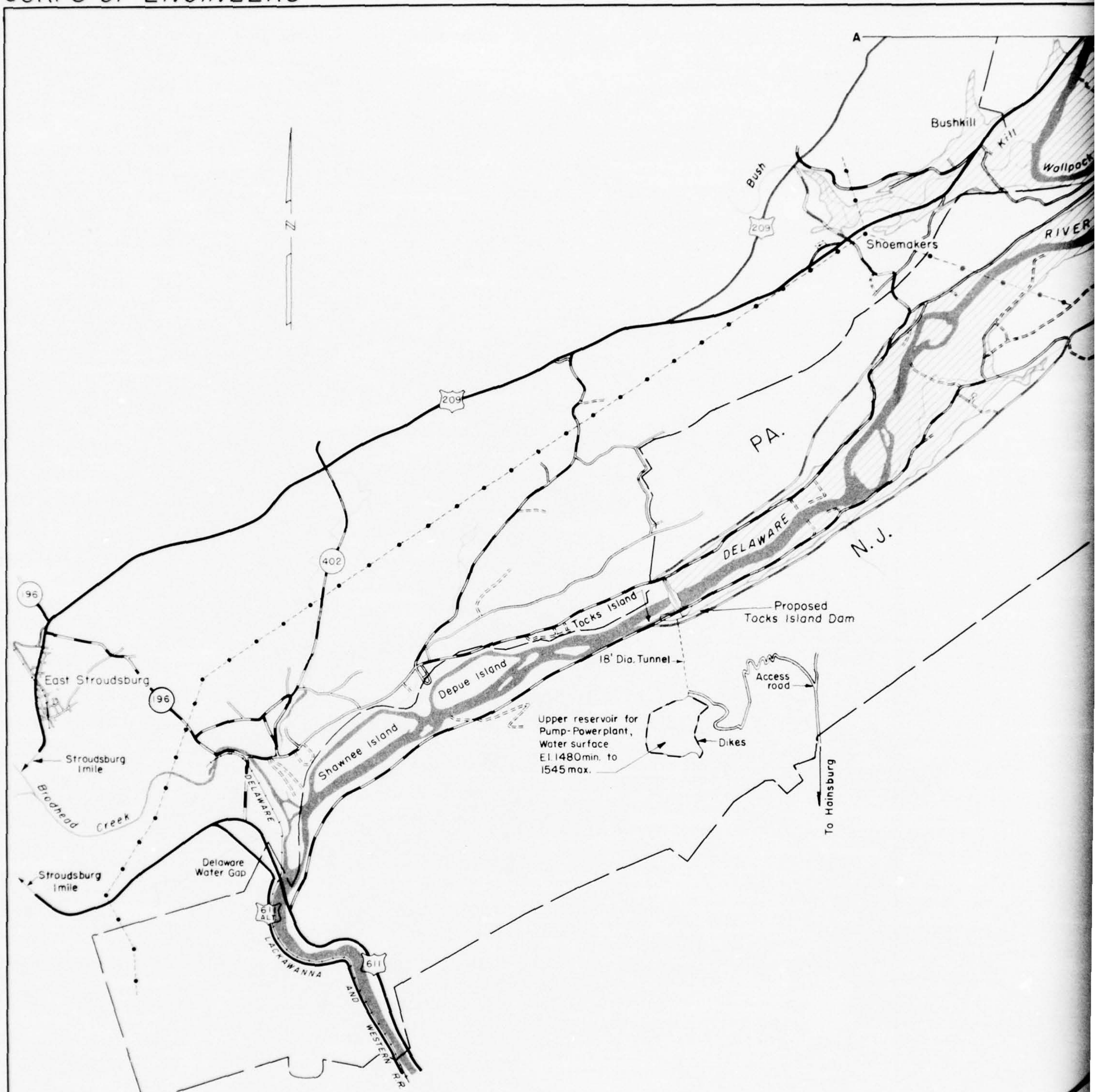
Philadelphia District
June 1960
Revised Oct. 1960

Drawer No. 228

File No. 29101

PLATE II

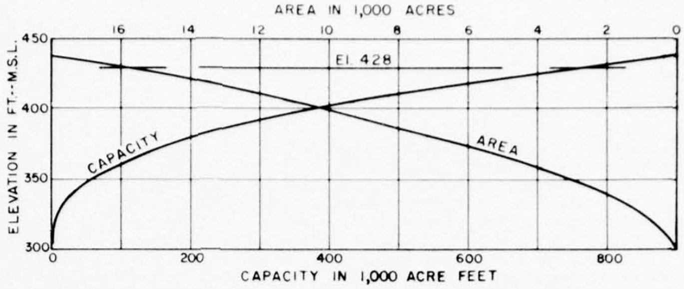
CORPS OF ENGINEERS



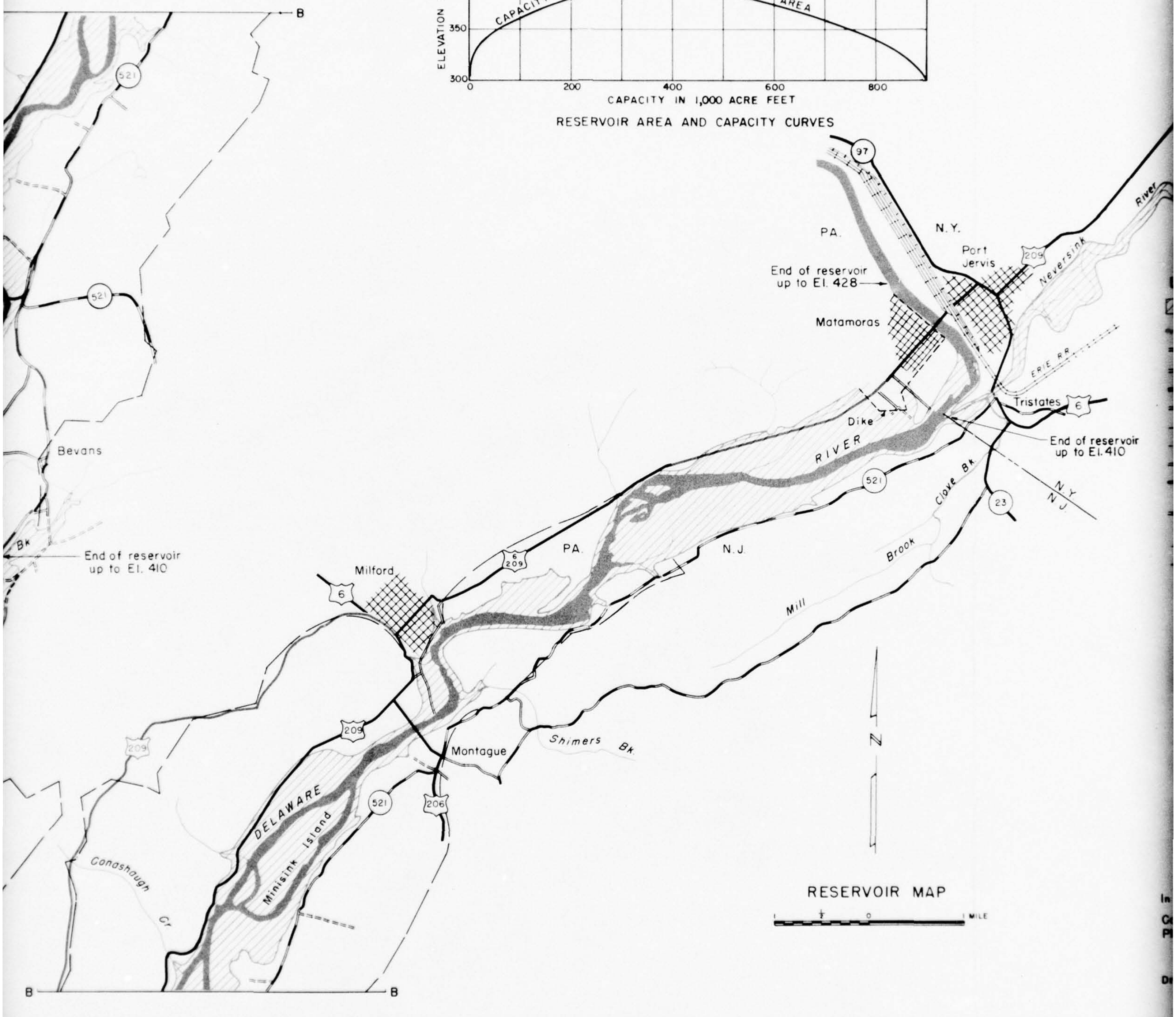
2

A
A
Bushkill
Kill
Flatbrookville
Bk.
Wallpack Bend
Flat
RIVER
Shoemakers
Millbrook
Vancampens Brook
N.J.
am
B
Adams Cr.
521
Dingmans
Ferry
521
209
RIVER
Bevans
209
Bk
End of reservoir
up to El. 410
PA.
DELAWARE
Flat
N.J.
209
Conashaugh Cr
A
A
B

3



RESERVOIR AREA AND CAPACITY CURVES



RESERVOIR MAP

4

U.S. ARMY

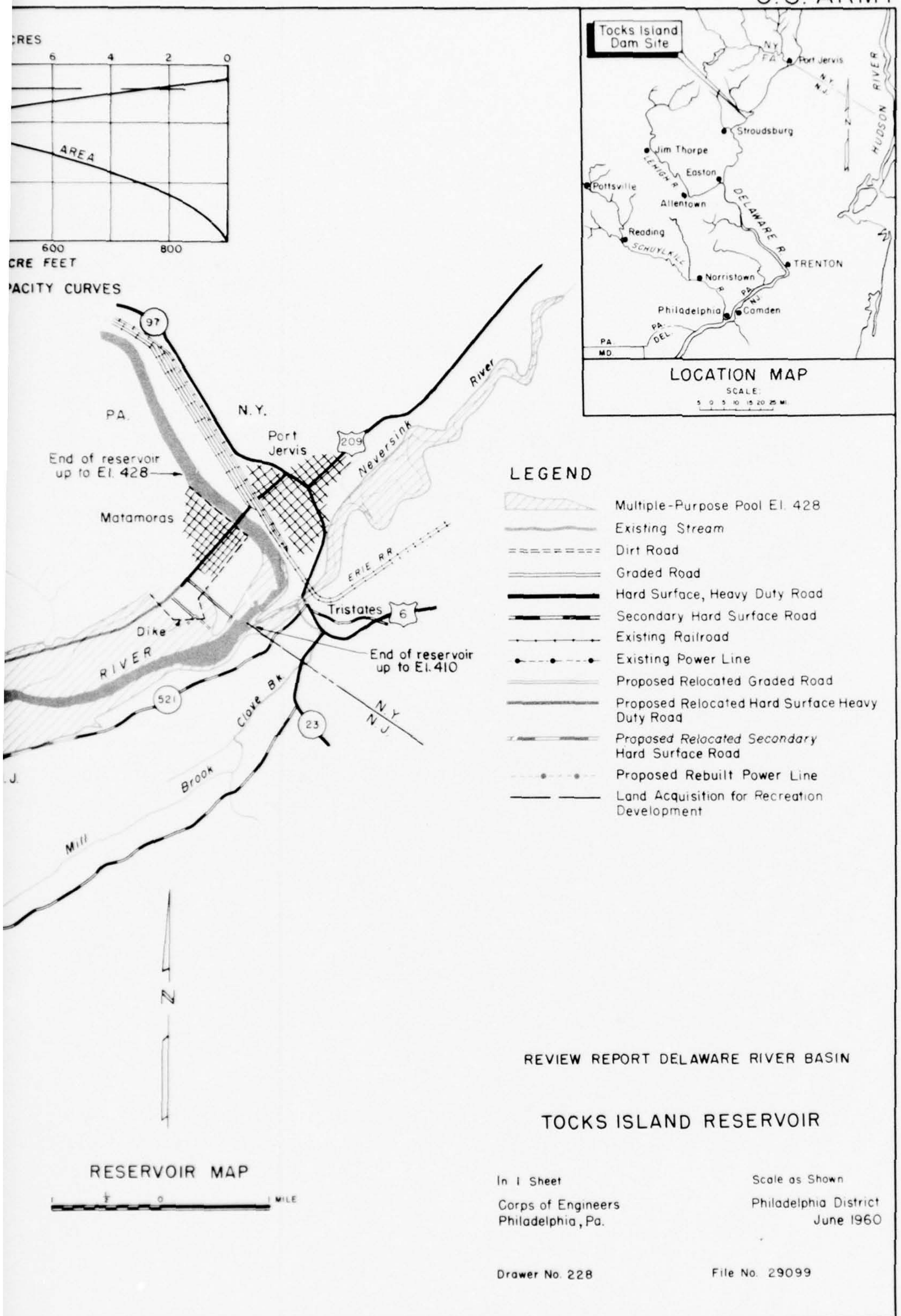
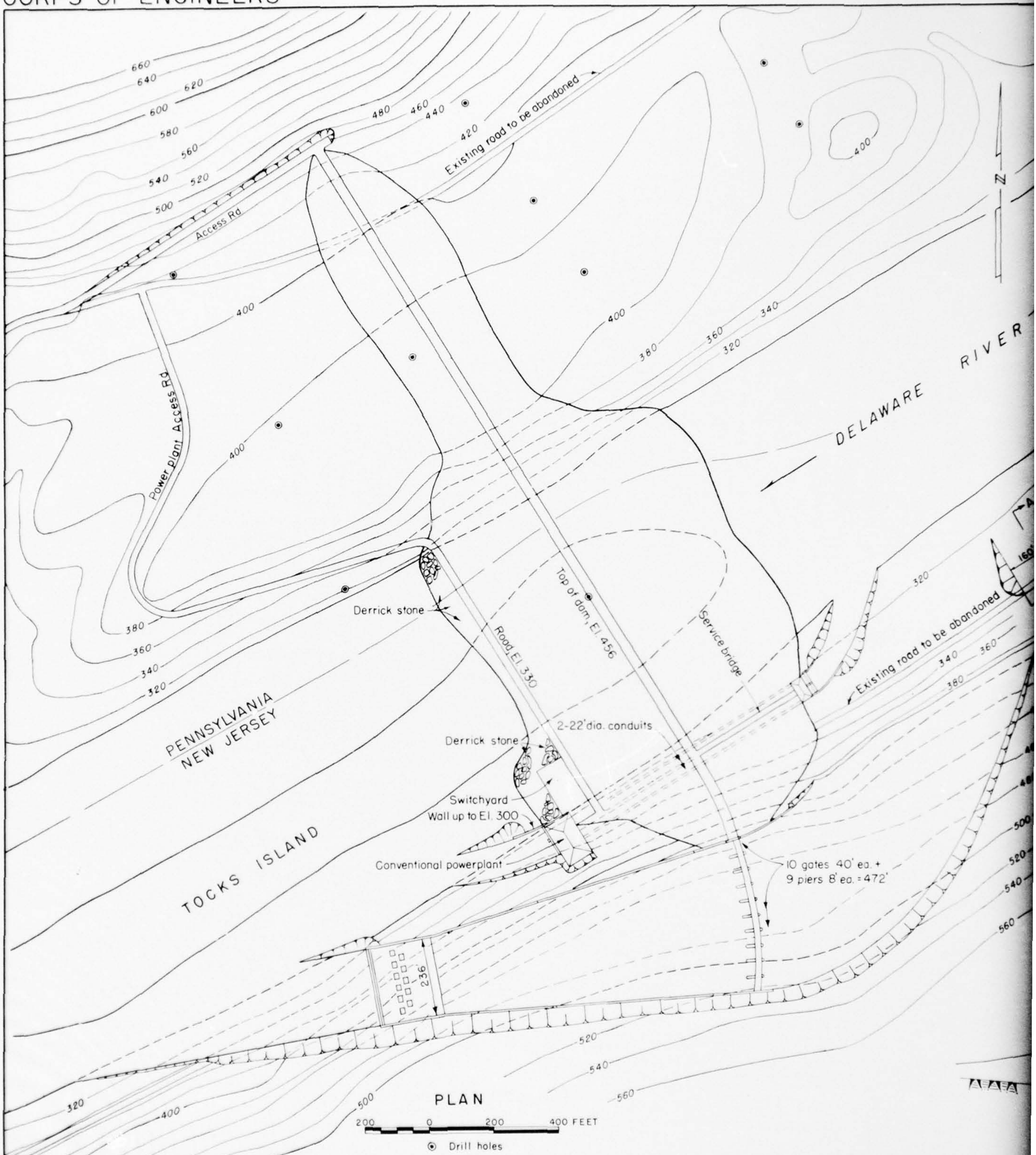


PLATE 12

CORPS OF ENGINEERS



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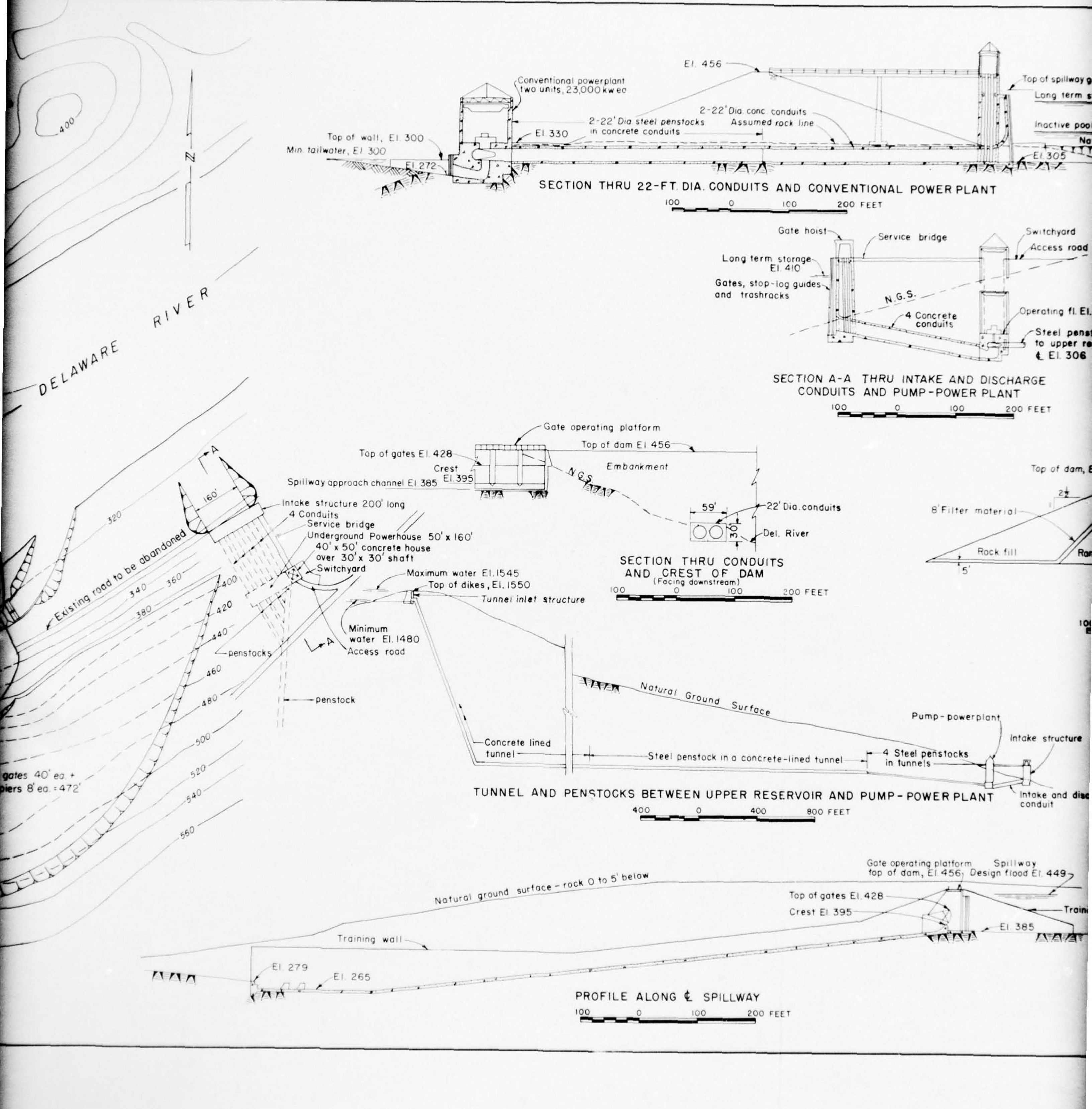
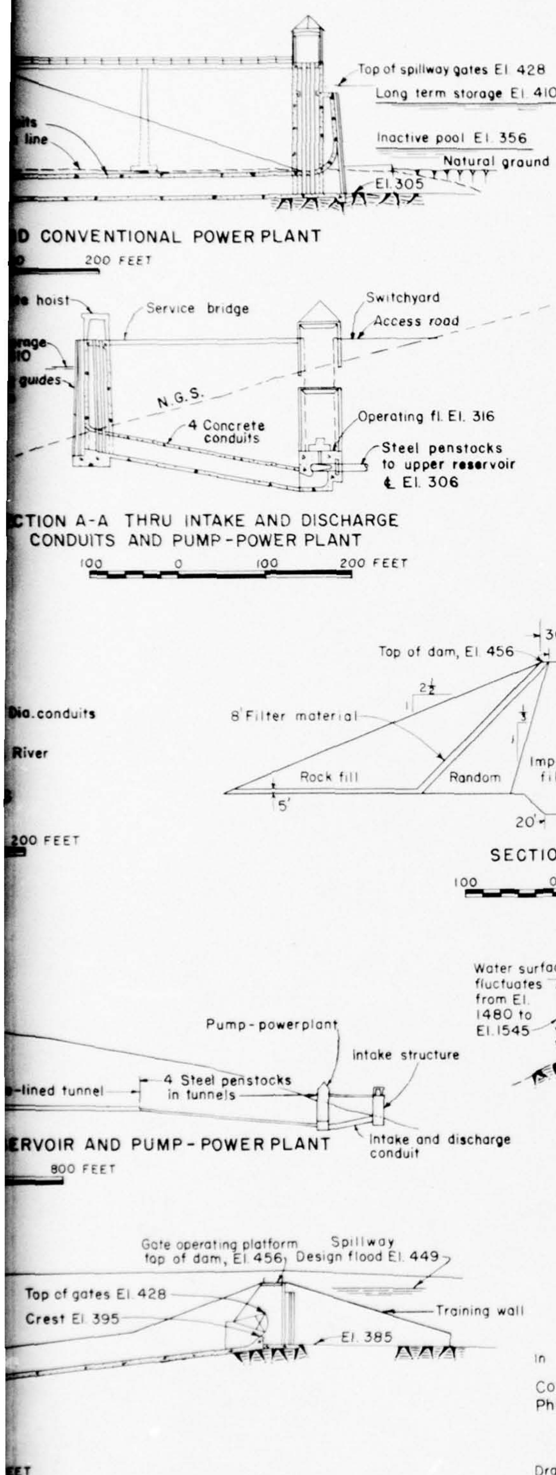
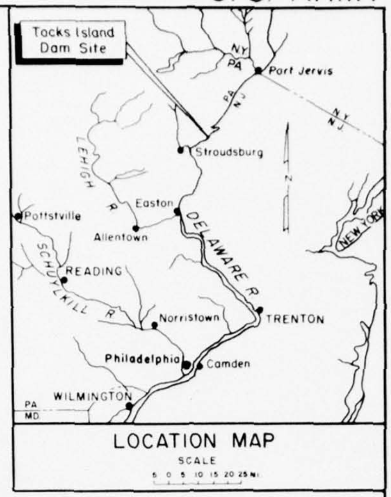
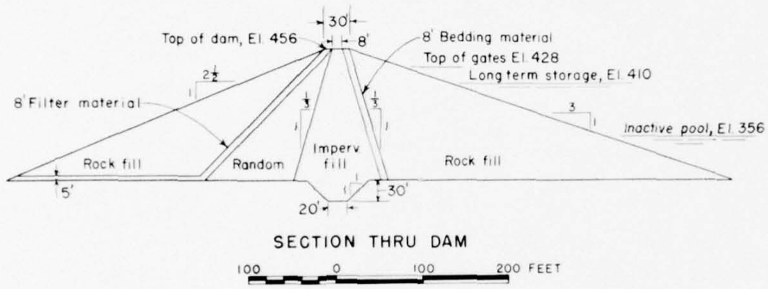


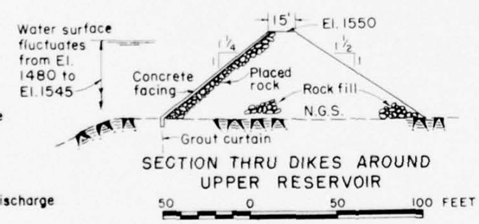
DELAWARE RIVER
N
400
320
340
360
380
400
420
440
460
480
500
520
540
560
Existing road to be abandoned
160'
A
Intake structure 200' long
4 Conduits
Service bridge
Underground Powerhouse 50' x 160'
40' x 50' concrete house
over 30' x 30' shaft
Switchyard
penstocks
penstock
Access road
gates 40' ea. +
piers 8' ea. = 472'
El. 456
Conventional powerplant
two units, 23,000 kw ea
2-22' Dia. conc. conduits
2-22' Dia. steel penstocks
in concrete conduits
Assumed rock line
Top of wall, El. 300
Min. tailwater, El. 300
El. 330
El. 272
El. 305
Top of spillway g
Long term s
Inactive poo
SECTION THRU 22-FT. DIA. CONDUITS AND CONVENTIONAL POWER PLANT
100 0 100 200 FEET
Gate hoist
Service bridge
Switchyard
Access road
Long term storage
El. 410
Gates, stop-log guides
and trashracks
N.G.S.
4 Concrete
conduits
Operating fl. El.
Steel pens
to upper re
℄ El. 306
SECTION A-A THRU INTAKE AND DISCHARGE
CONDUITS AND PUMP-POWER PLANT
100 0 100 200 FEET
Gate operating platform
Top of gates El. 428
Top of dam El. 456
Crest
El. 395
Spillway approach channel El. 385
Embankment
N.G.S.
59'
22' Dia. conduits
30'
Del. River
SECTION THRU CONDUITS
AND CREST OF DAM
(Facing downstream)
100 0 100 200 FEET
Top of dam, E
8' Filter material
Rock fill
5'
Maximum water El. 1545
Top of dikes, El. 1550
Tunnel inlet structure
Minimum
water El. 1480
Natural Ground Surface
Pump-powerplant
Intake structure
Concrete lined
tunnel
Steel penstock in a concrete-lined tunnel
4 Steel penstocks
in tunnels
Intake and dis
conduit
TUNNEL AND PENSTOCKS BETWEEN UPPER RESERVOIR AND PUMP-POWER PLANT
400 0 400 800 FEET
Gate operating platform
top of dam, El. 456
Spillway
Design flood El. 449
Natural ground surface - rock 0 to 5' below
Top of gates El. 428
Crest El. 395
Train
El. 385
Training wall
El. 279
El. 265
PROFILE ALONG ℄ SPILLWAY
100 0 100 200 FEET

U.S. ARMY









REVIEW REPORT DELAWARE RIVER BASIN

TOCKS ISLAND DAM

In 1 Sheet

Scales as Shown

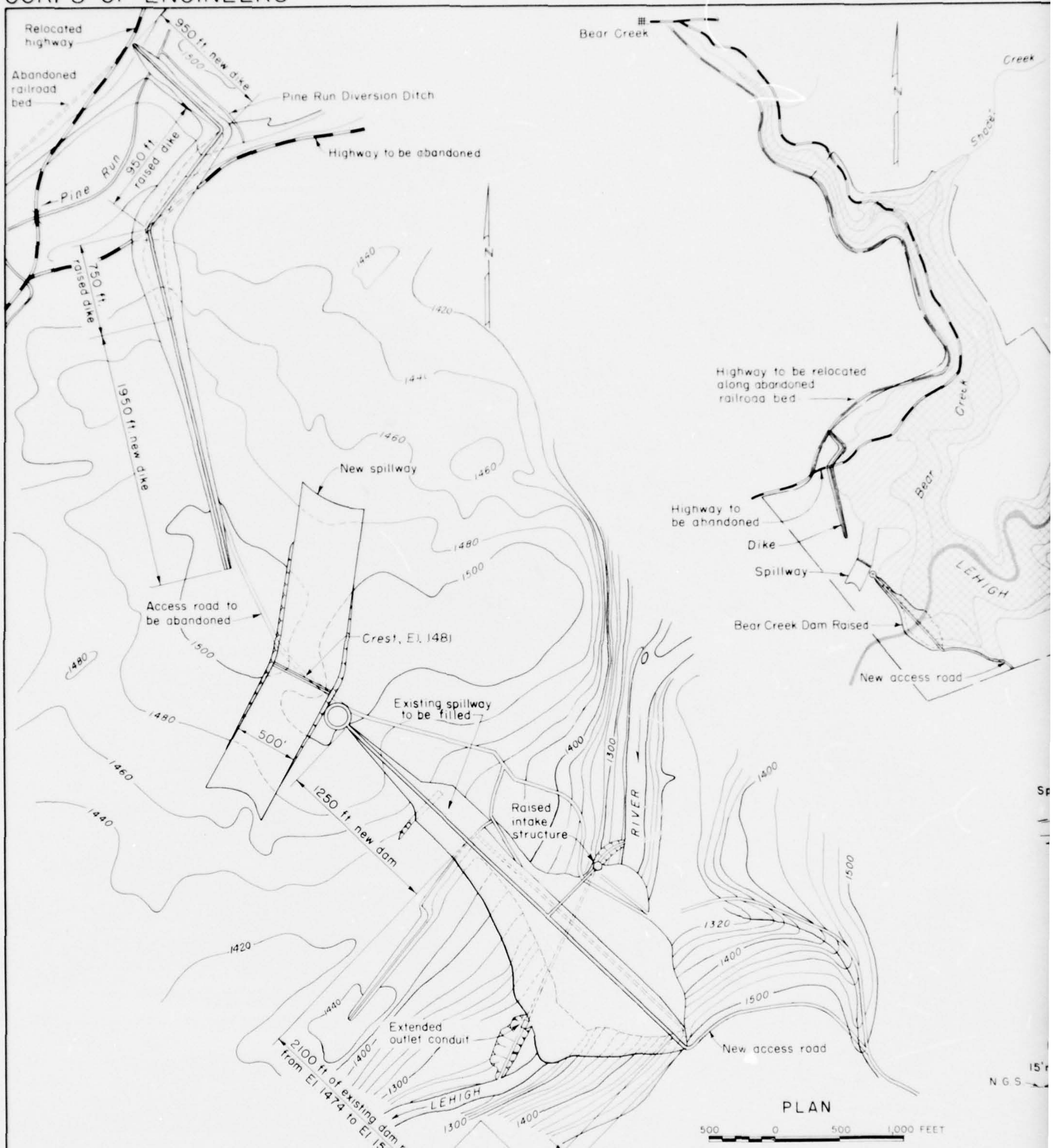
Corps of Engineers
Philadelphia, Pa.

Philadelphia District
June 1960
Revised Oct. 1960

Drawer No. 228

File No. 29098

CORPS OF ENGINEERS



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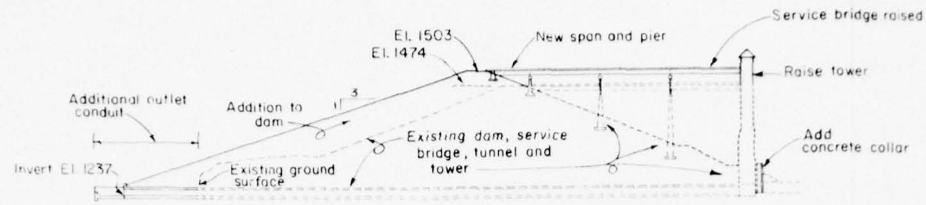
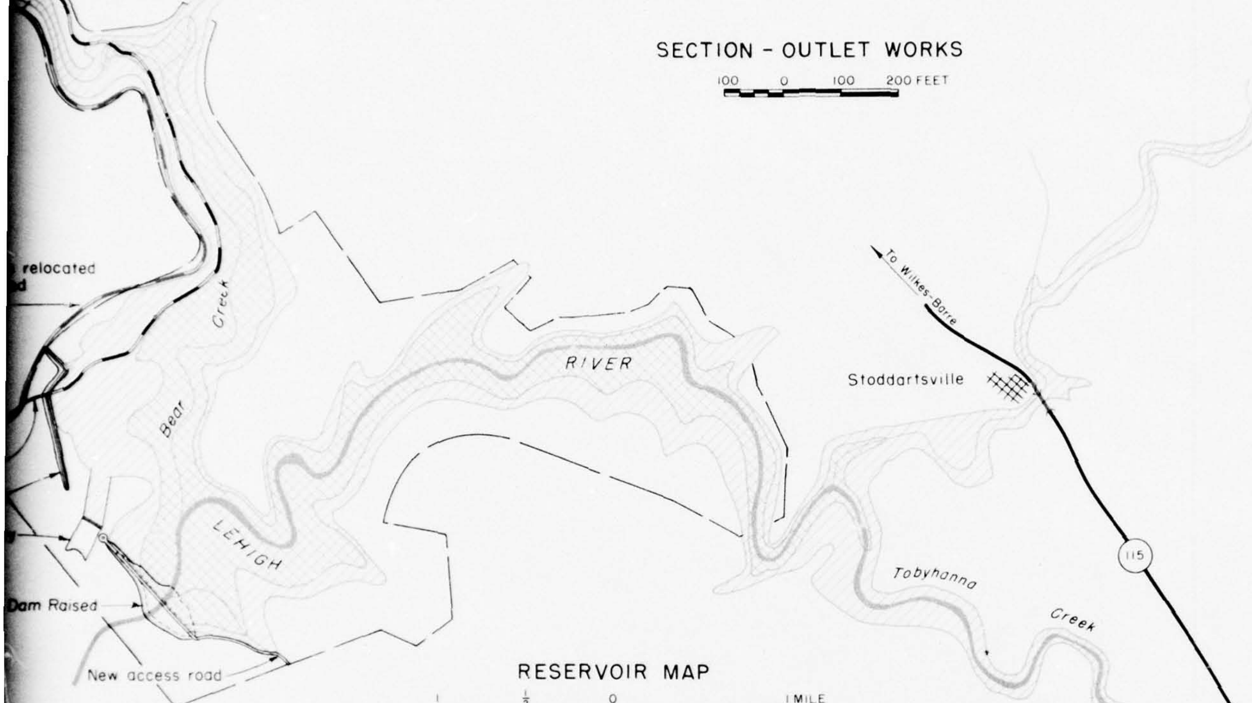


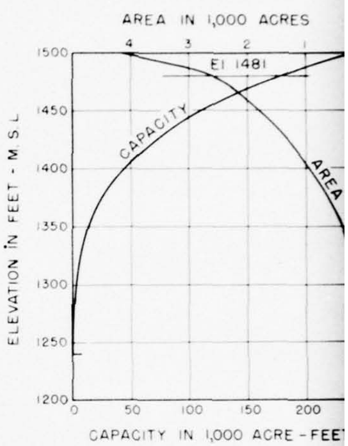
SECTION - OUTLET WORKS

100 0 100 200 FEET

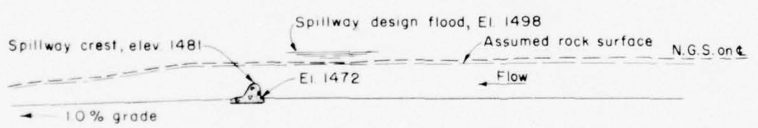


RESERVOIR MAP

1 ½ 0 1 MILE



RESERVOIR AREA AND CAPACITY

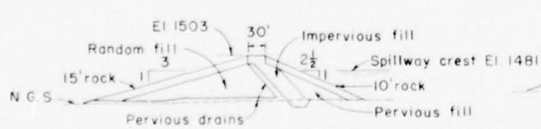


PROFILE ALONG ℄ OF SPILLWAY

50 0 50 100 FEET

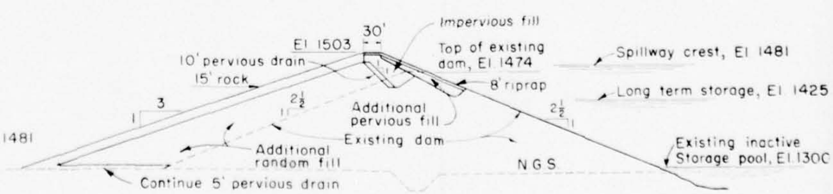
LAN

500 1,000 FEET



SECTION - NEW DAM

100 0 100 200 FEET

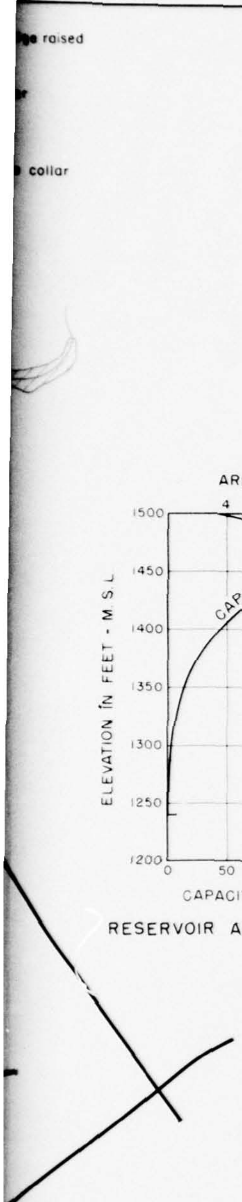


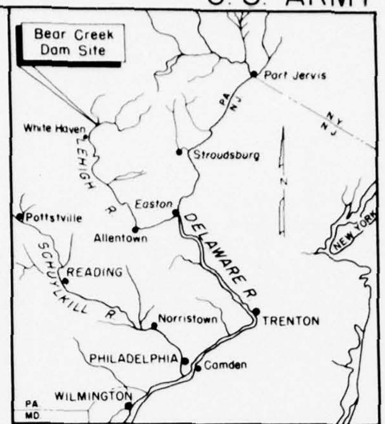
SECTION - RAISED DAM

100 0 100 200 FEET

3

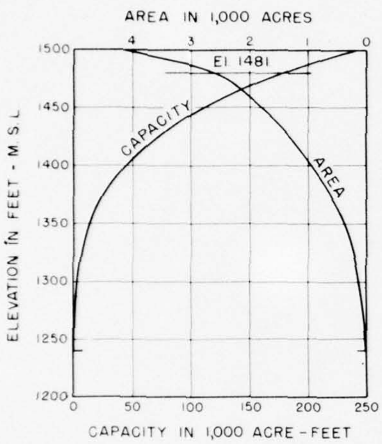
U. S. ARMY





LOCATION MAP

SCALE

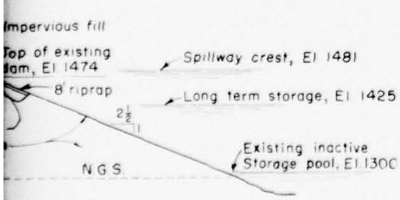


RESERVOIR AREA AND CAPACITY CURVES

LEGEND

- Reservoir at El. 1481
- Long Term Storage El. 1425
- Existing Stream
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Land Acquisition for Recreation Development
- Outline of Existing Structure

Note: Topographic data from field surveys by Philadelphia District in 1954.



D DAM

200 FEET

REVIEW REPORT DELAWARE RIVER BASIN

BEAR CREEK PROJECT
WITH DAM RAISED TO EL. 1503

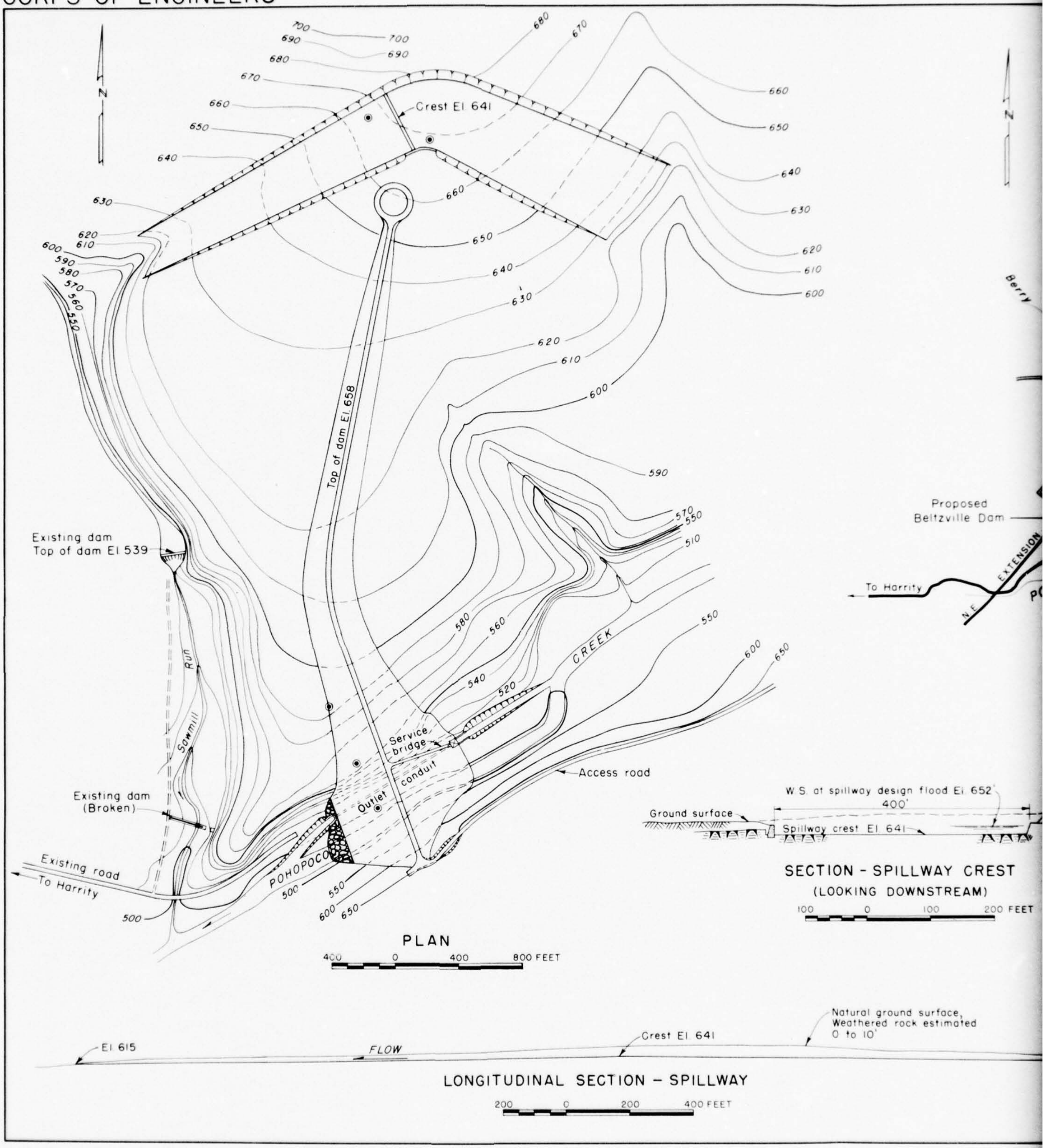
In 1 Sheet | Scale as Shown

Corps of Engineers
Philadelphia, Pa.

Philadelphia District
June 1960

Drawer No. 228 | File No. 29100

CORPS OF ENGINEERS



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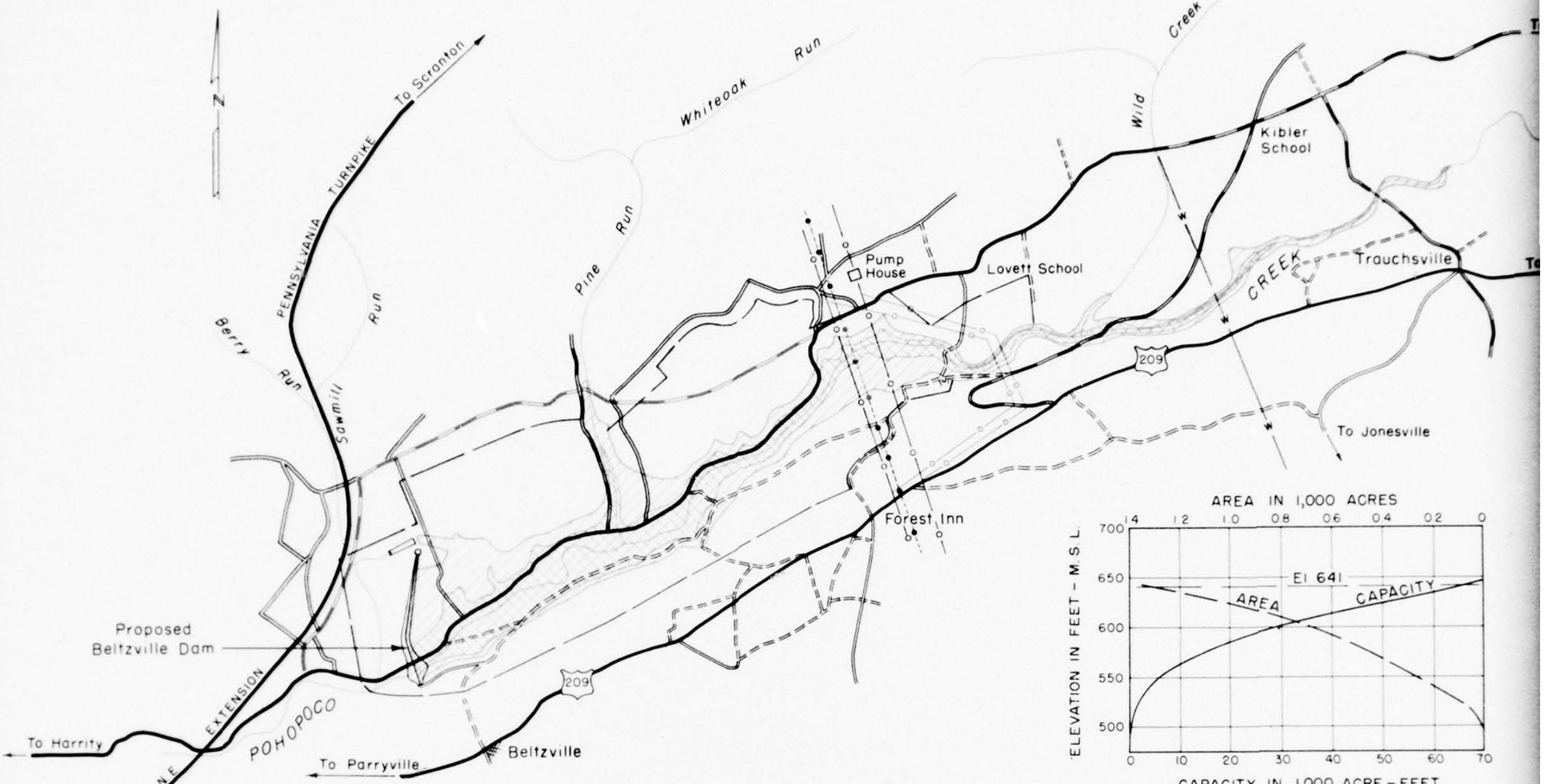
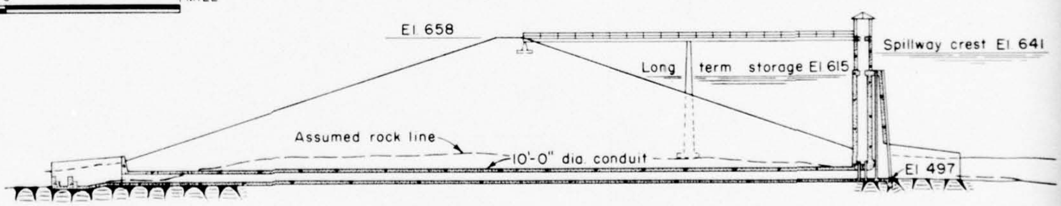


RESERVOIR MAP

1 0 1 MILE

RESERVOIR AREA AND CAPACITY CURVES

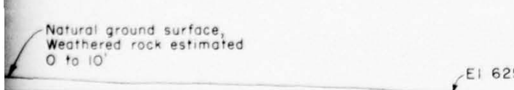


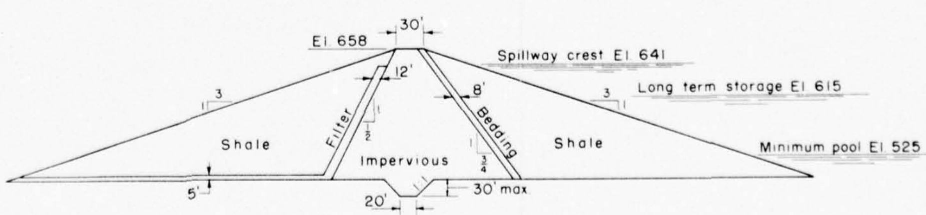
SECTION - OUTLET WORKS

100 0 100 200 FEET

CTION - SPILLWAY CREST
(LOOKING DOWNSTREAM)

00 0 100 200 FEET



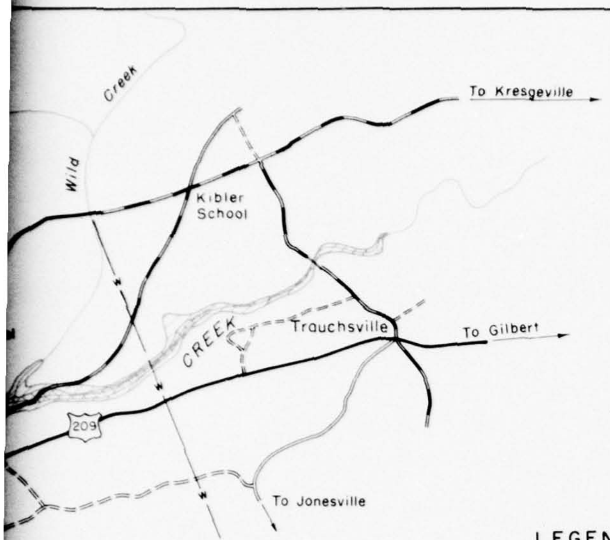


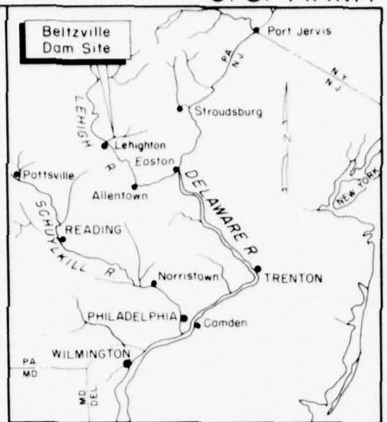
TYPICAL SECTION - DAM

100 0 100 200 FEET

3

U.S. ARMY

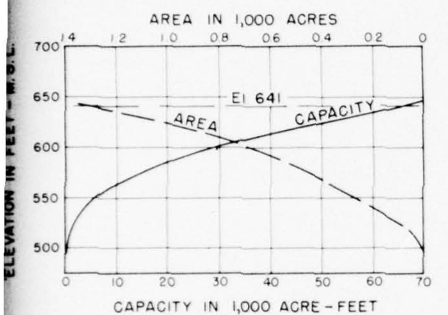




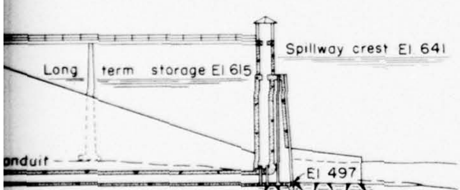
LOCATION MAP

SCALE

5 0 5 10 15 20 25 MI

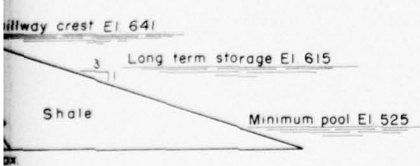


RESERVOIR AREA AND CAPACITY CURVES



ORKS

200 FEET



AM

200 FEET

LEGEND

- Reservoir at El. 641
- Long Term Storage El. 615
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Power Line
- Existing Oil Line
- Existing Water Line
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Power Line
- Proposed Relocated Oil Line
- Land Acquisition for Recreation Development
- Drill Hole

Note: Topography at dam site taken from U.S. Geological Survey maps modified by cross sections obtained in field.

REVIEW REPORT DELAWARE RIVER BASIN

BELTZVILLE PROJECT

In 1 Sheet

Scale as Shown

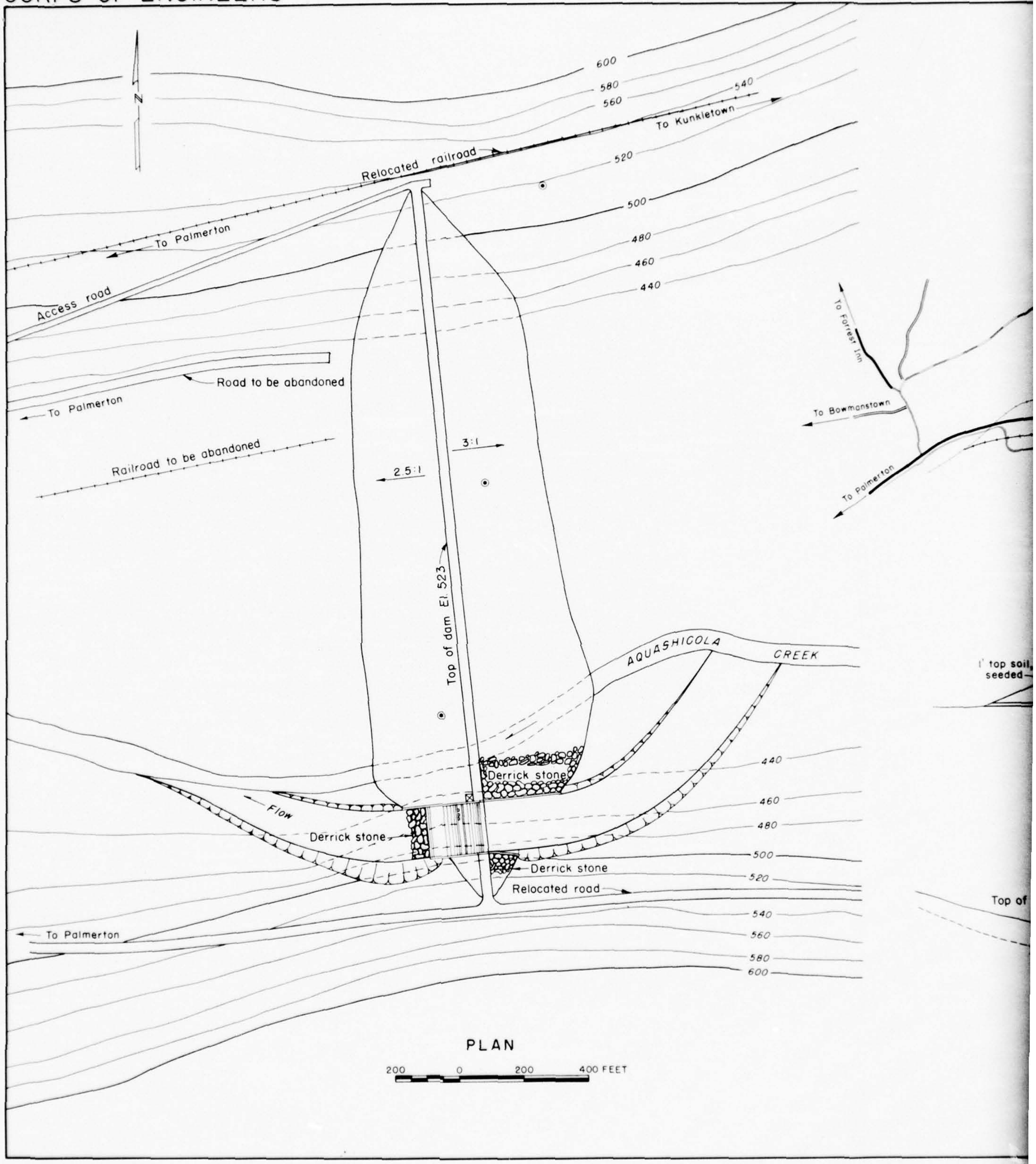
Corps of Engineers
Philadelphia, Pa.

Philadelphia District
June 1960
Revised Nov 1960

Drawer No. 228

File No. 29095

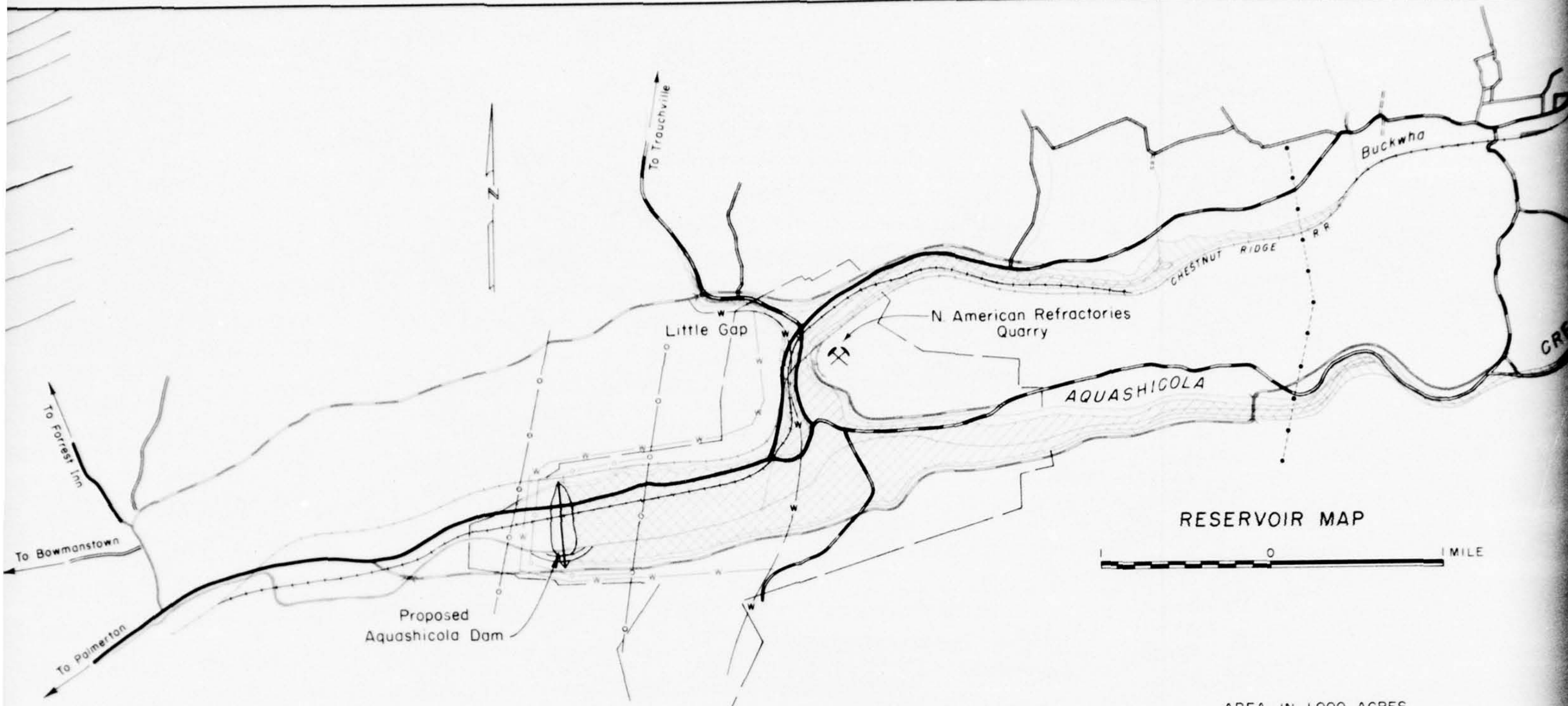
CORPS OF ENGINEERS



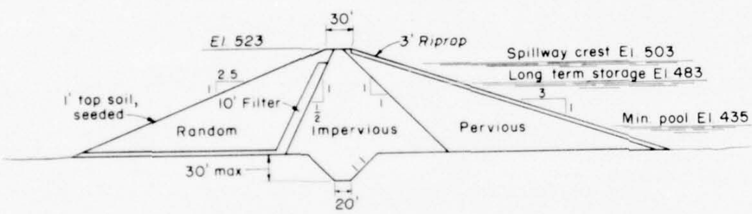
PLAN

200 0 200 400 FEET

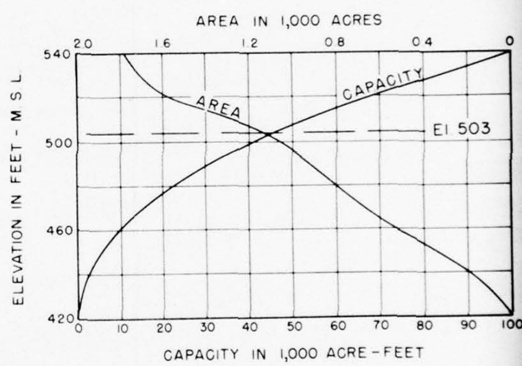
2



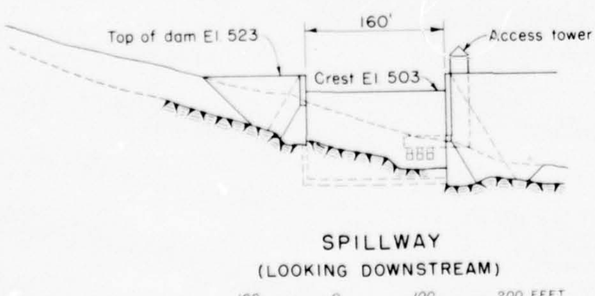
RESERVOIR MAP



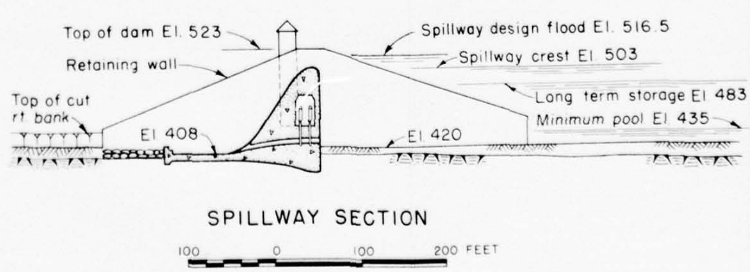
TYPICAL SECTION - DAM



RESERVOIR AREA AND CAPACITY CURVES

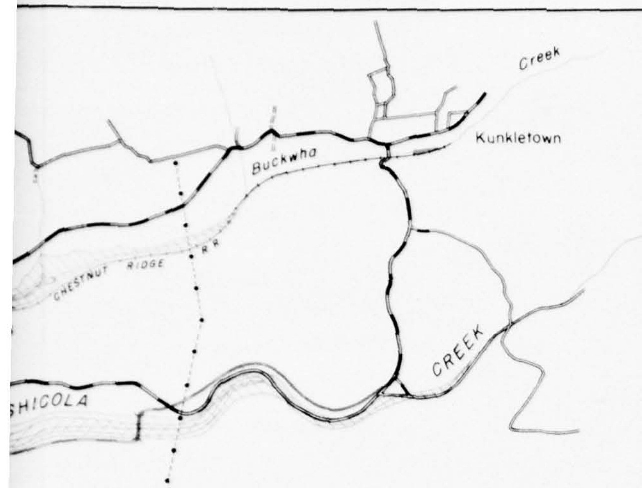


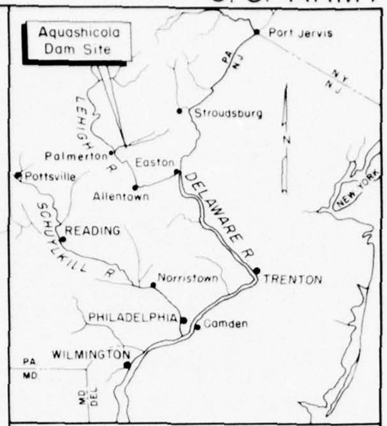
SPILLWAY
(LOOKING DOWNSTREAM)



SPILLWAY SECTION

U.S. ARMY





LOCATION MAP

SCALE

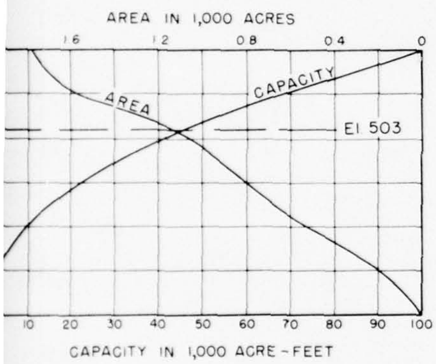
5 0 5 10 15 20 25 MI

RESERVOIR MAP

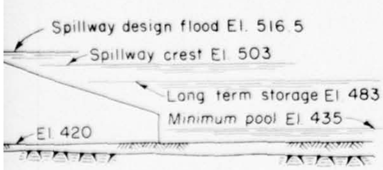
0 1 MILE

LEGEND

- Reservoir at El. 503
- Long Term Storage El. 483
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Railroad
- Existing Power Line
- Existing Petroleum Line
- Existing Water Line
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Railroad
- Proposed Relocated Petroleum Line
- Proposed Relocated Water Line
- Land Acquisition for Recreation Development
- Quarry
- Drill Hole



RESERVOIR AREA AND CAPACITY CURVES



TION

200 FEET

REVIEW REPORT DELAWARE RIVER BASIN

AQUASHICOLA PROJECT

In 1 Sheet

Scale as Shown

Corps of Engineers
Philadelphia, Pa.

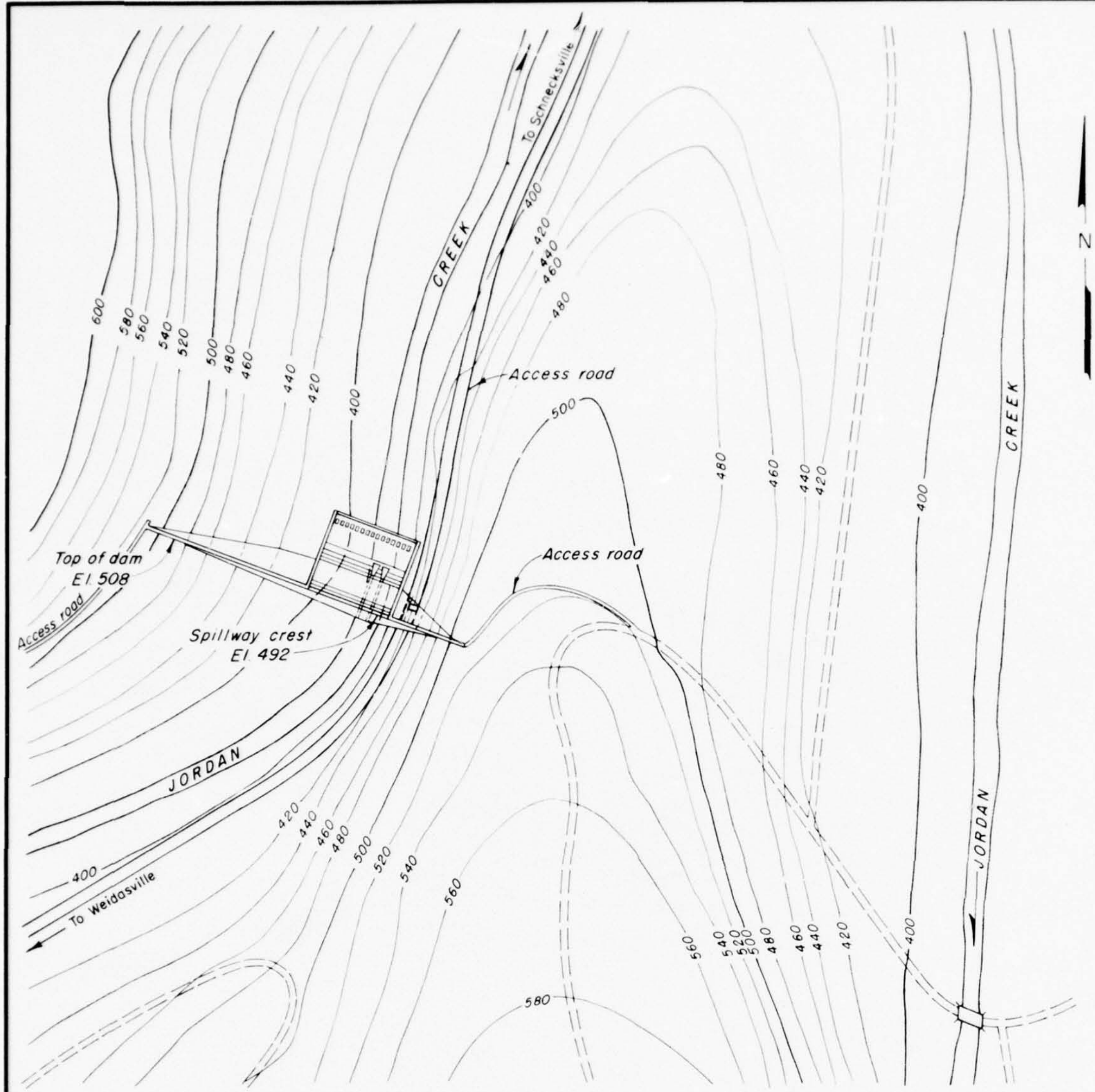
Philadelphia District
June 1960
Revised Oct. 1960

Drawer No. 228

File No. 29093

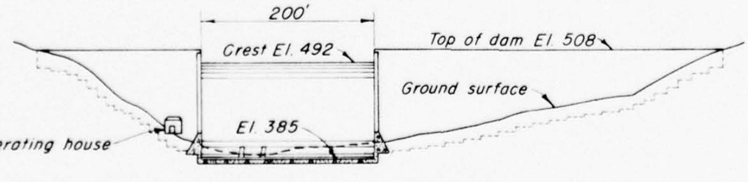
PLATE 16

CORPS OF ENGINEERS



PLAN

200 0 200 400 FEET

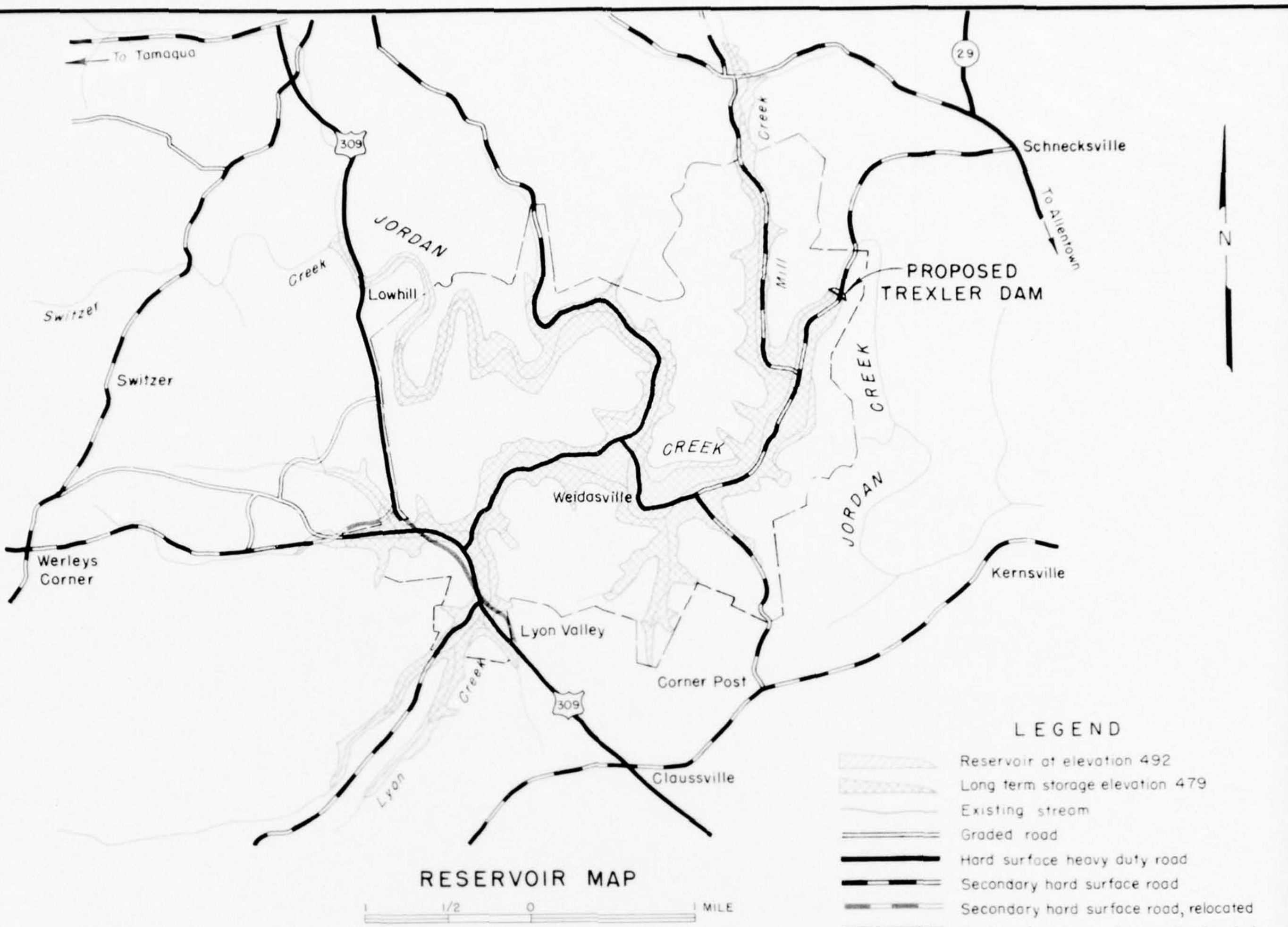


ELEVATION - CONCRETE DAM

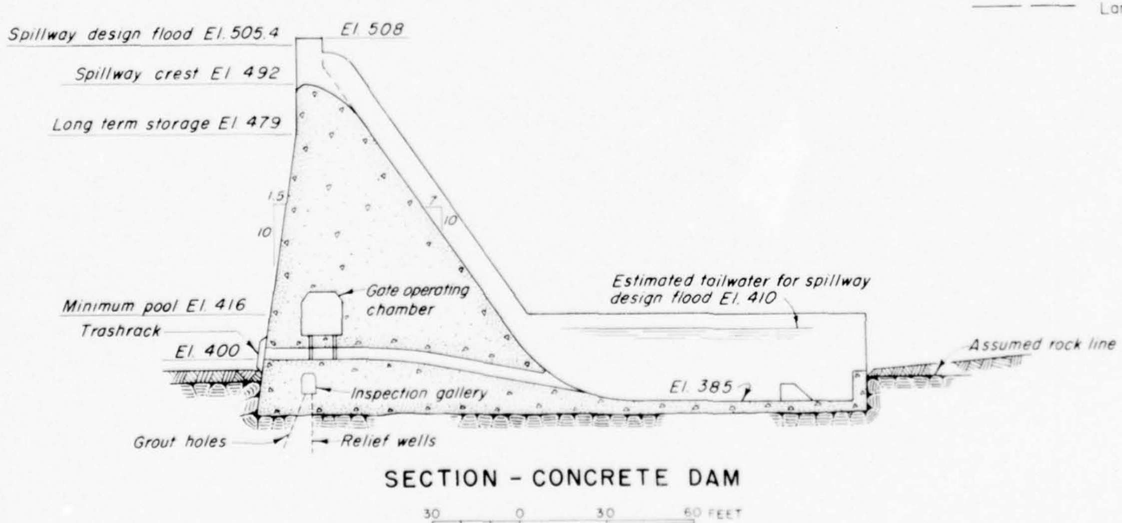
LOOKING UPSTREAM

100 0 100 200 300 FEET

2



RESERVOIR MAP



SECTION - CONCRETE DAM

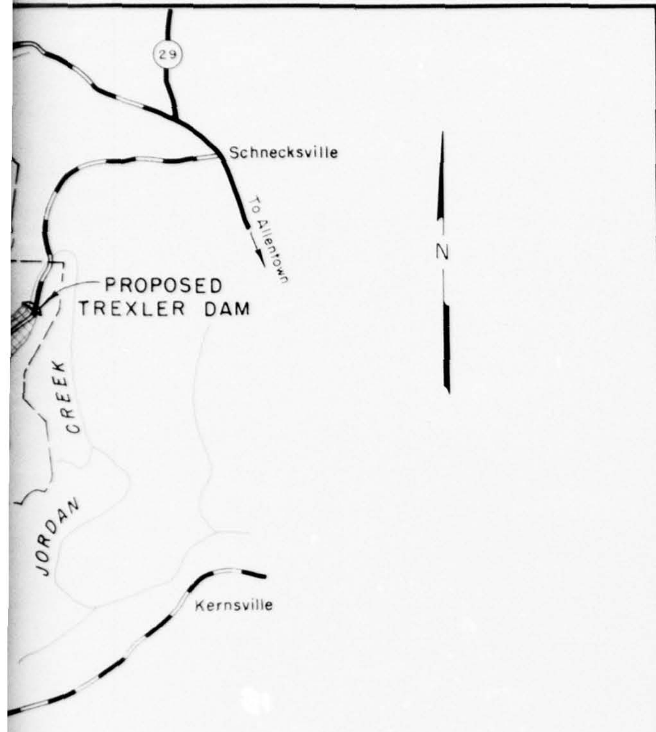
REV

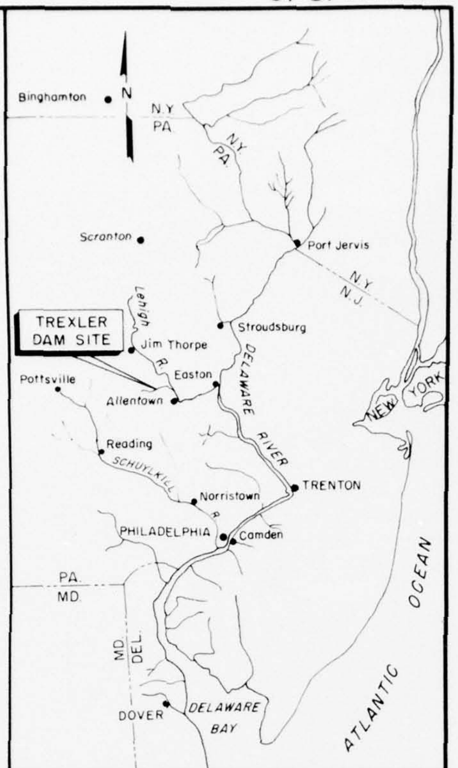
In 1 sheet
Corps of E

Drawer No.

3

U. S. ARMY





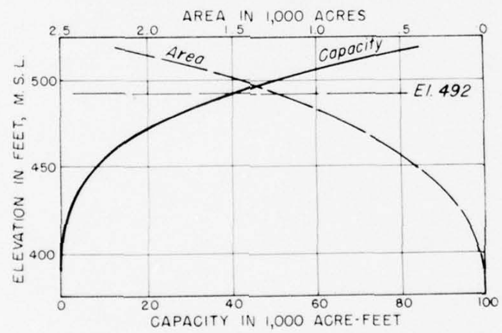
LOCATION MAP

SCALE

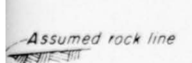
10 0 10 20 30 40 MI

LEGEND

Reservoir at elevation 492
Long term storage elevation 479
Existing stream
Graded road
Hard surface heavy duty road
Secondary hard surface road
Secondary hard surface road, relocated
Hard surface heavy duty road, relocated
Land acquisition for recreation development



AREA AND CAPACITY CURVES



REVIEW REPORT DELAWARE RIVER BASIN

TREXLER PROJECT

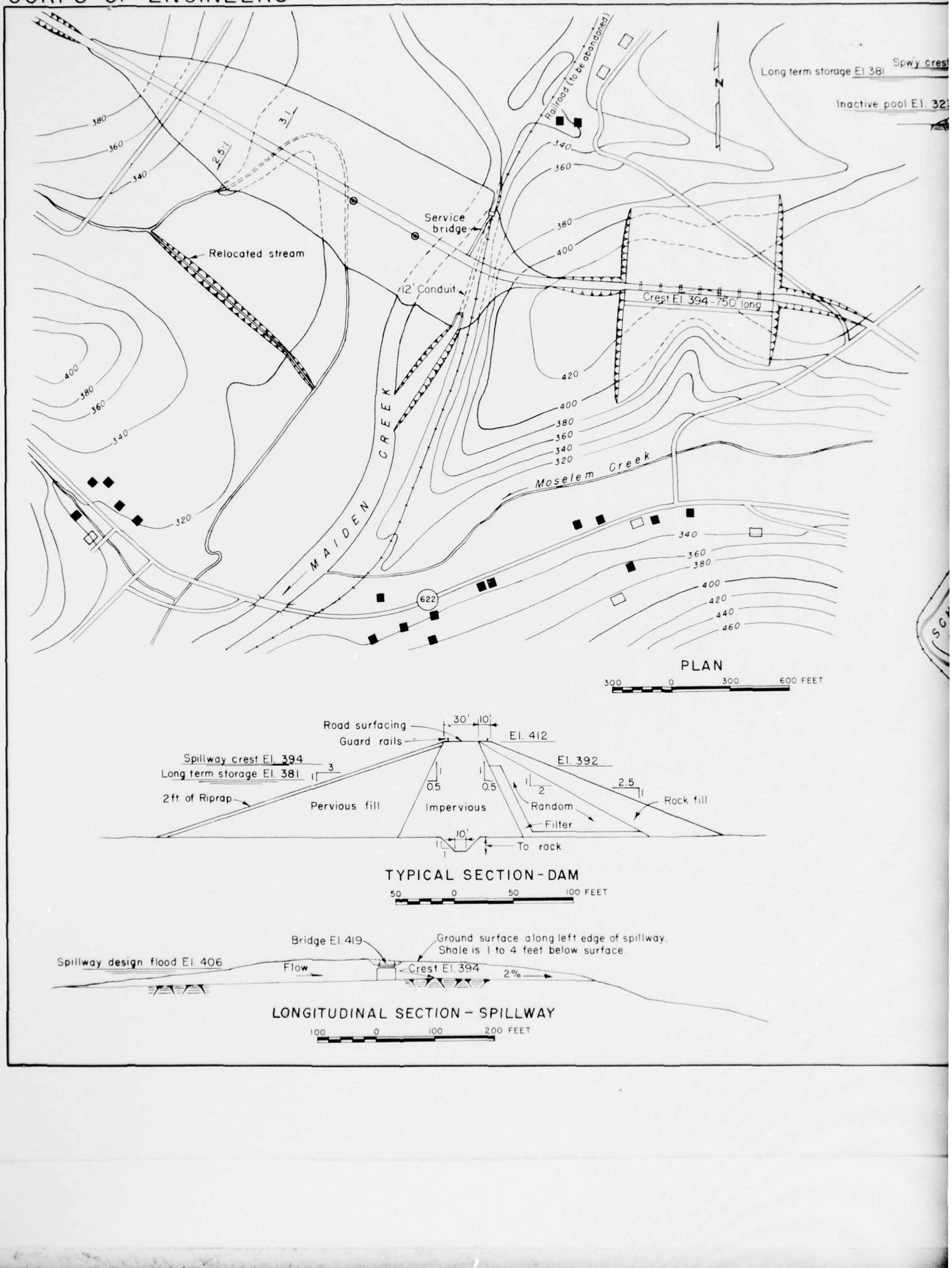
In 1 sheet
Corps of Engineers

Scale as shown
Philadelphia District

Drawer No. 228

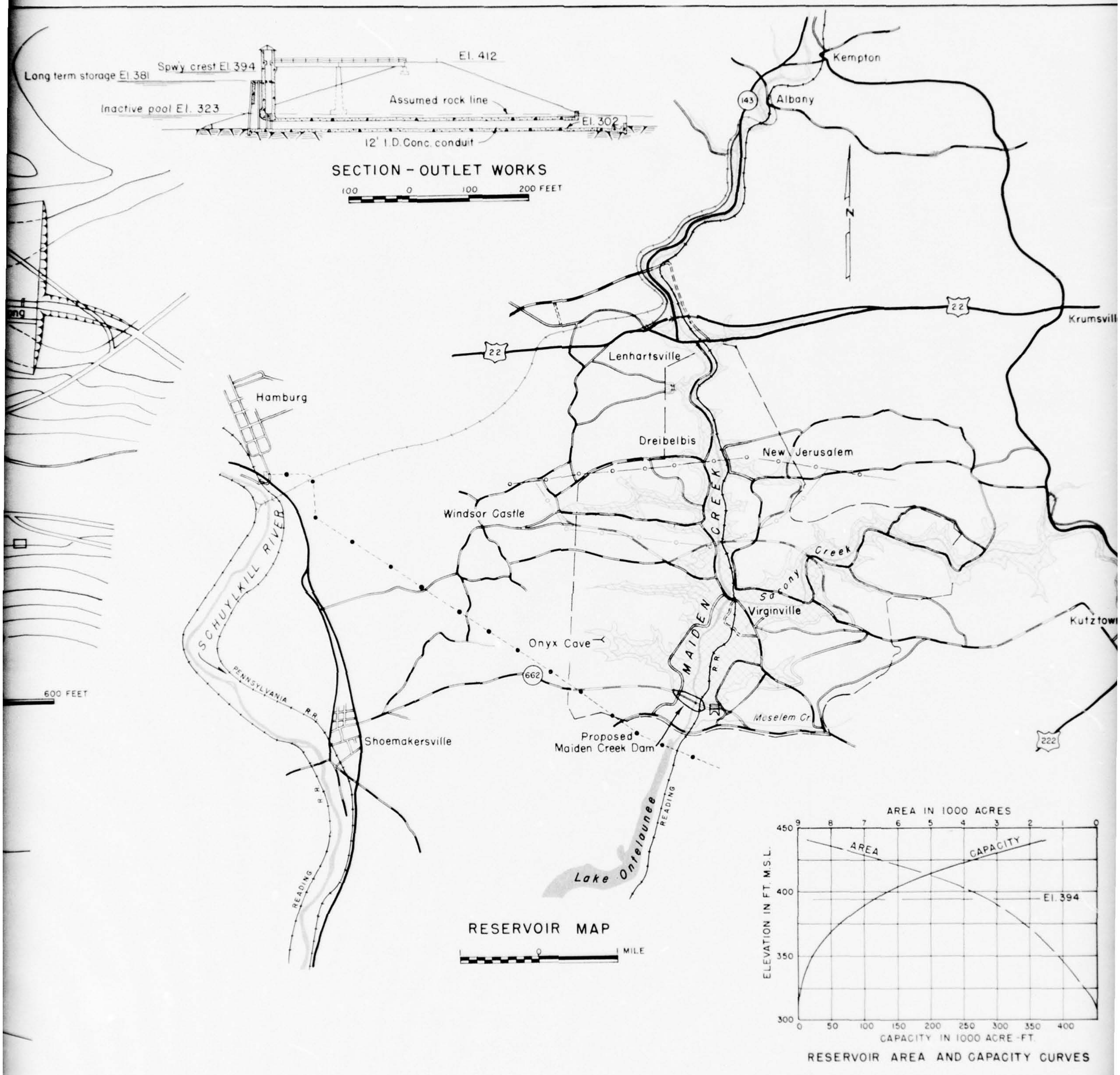
File No. 29097

CORPS OF ENGINEERS



CORPS OF ENGINEERS

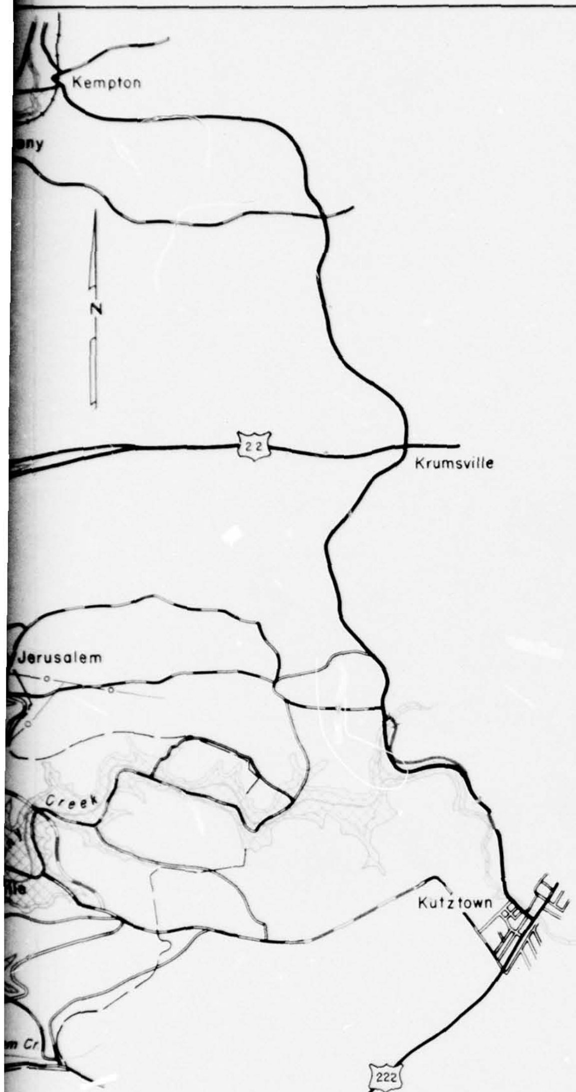
2

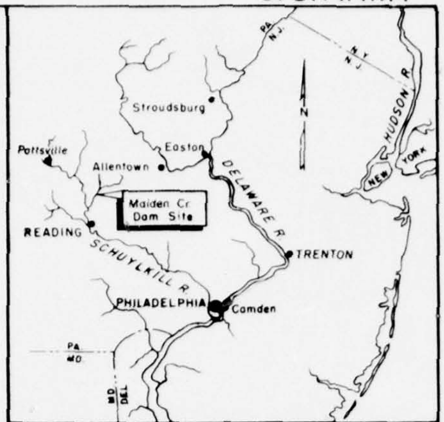


Long term storage El. 381
Spw'y crest El. 394
El. 412
Inactive pool El. 323
Assumed rock line
El. 302
12' I.D. Conc. conduit
SECTION - OUTLET WORKS
100 0 100 200 FEET
600 FEET
Kempton
Albany
143
N
22
Krumsville
Lenhartsville
Hamburg
Dreibelbis
New Jerusalem
Windsor Castle
SCHUYLKILL RIVER
MAIDEN CREEK
Sacony Creek
Virginville
Kutztown
Onyx Cave
662
PENNSYLVANIA R.R.
Shoemakersville
Moselem Cr.
Proposed Maiden Creek Dam
222
Lake Ontelaunee
READING
R.R.
RESERVOIR MAP
MILE
AREA IN 1000 ACRES
AREA
CAPACITY
El. 394
ELEVATION IN FT. M.S.L.
CAPACITY IN 1000 ACRE-FT.
RESERVOIR AREA AND CAPACITY CURVES

3

U.S. ARMY



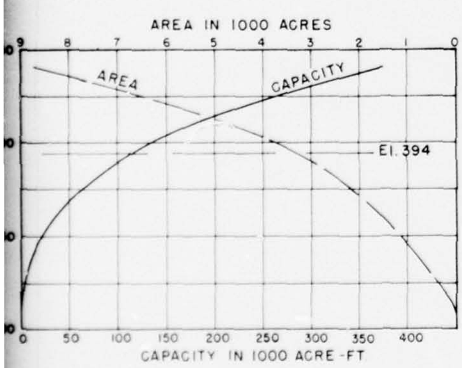


LOCATION MAP

SCALE

LEGEND

- Reservoir at El. 394
- Long Term Storage El. 381
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Railroad
- Existing Power Line
- Existing Petroleum Line
- Proposed Relocated Graded Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Railroad
- Proposed Relocated Petroleum Line
- Land Acquisition for Recreation Development
- Drill Hole



RESERVOIR AREA AND CAPACITY CURVES

REVIEW REPORT DELAWARE RIVER BASIN

MAIDEN CREEK PROJECT

In 1 Sheet | Scale as Shown

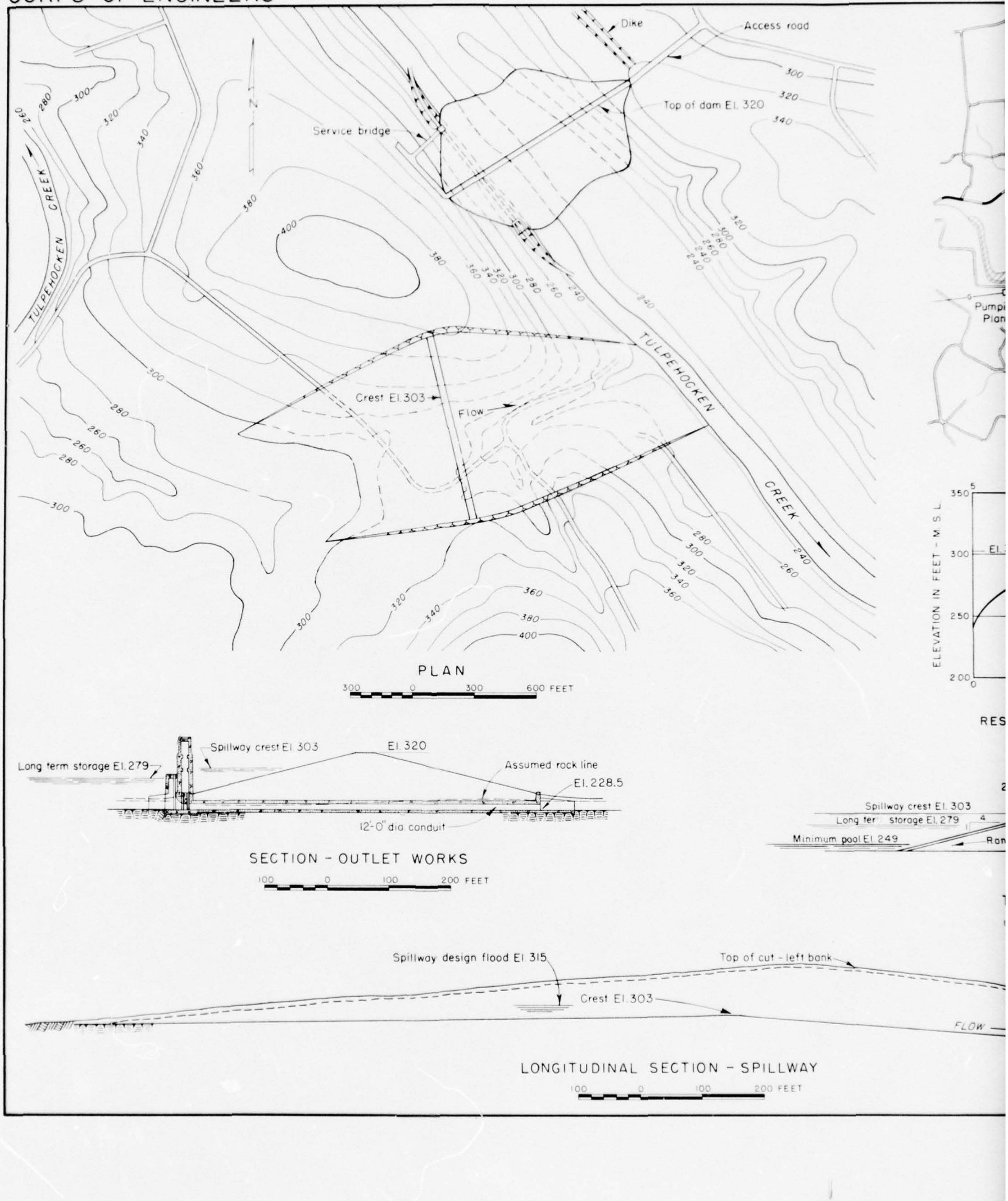
Corps of Engineers Philadelphia, Pa.

Philadelphia District
June 1960
Revised Oct. 1960

Drawer No. 228 | File No. 29094

PLATE 18

CORPS OF ENGINEERS



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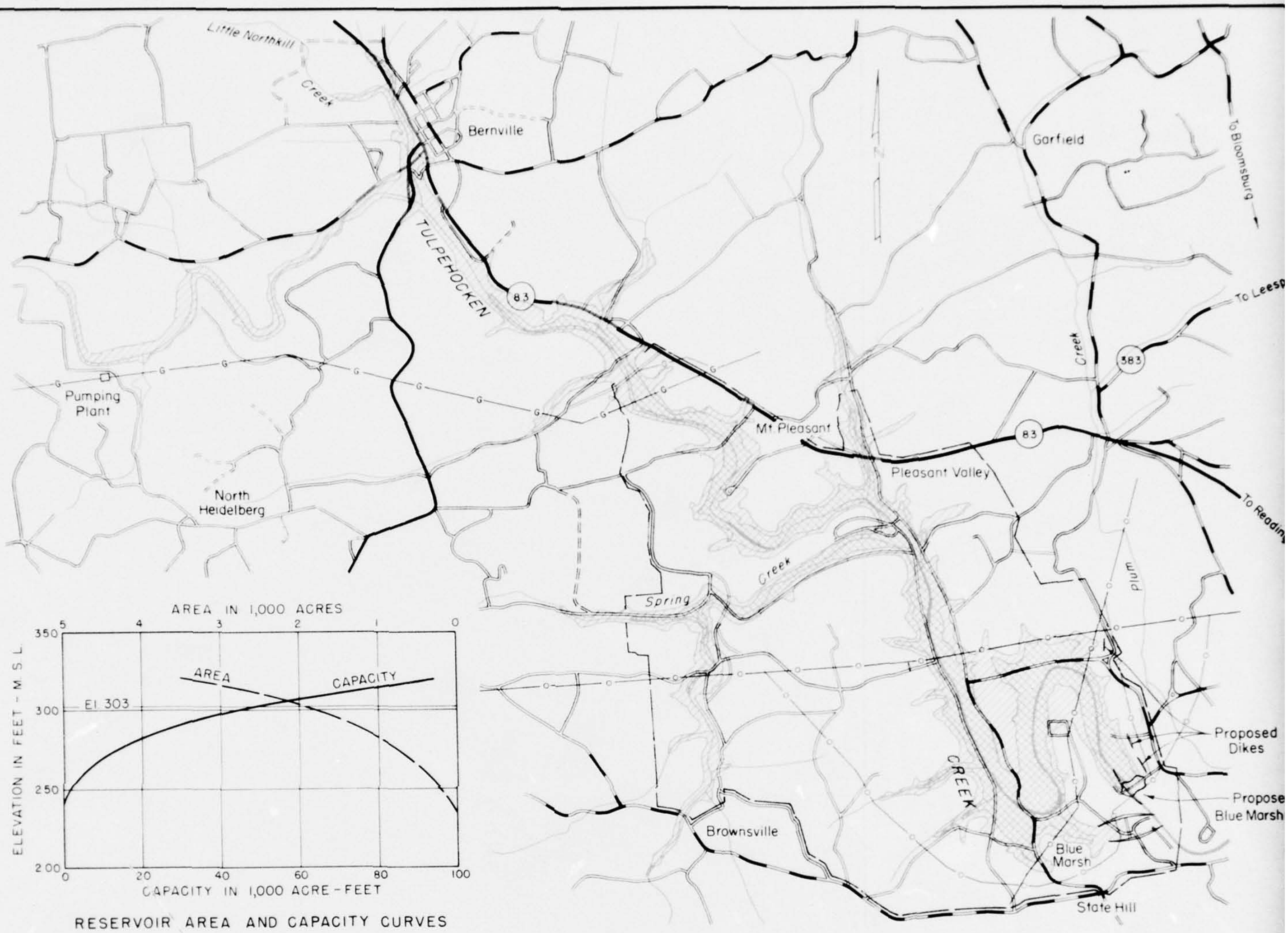
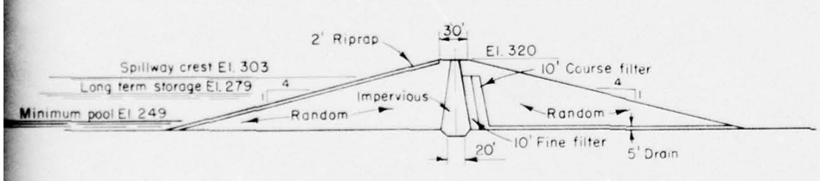


RESERVOIR AREA AND CAPACITY CURVES

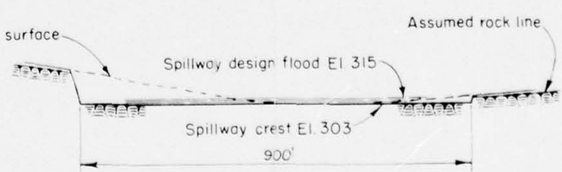
RESERVOIR MAP

1 ½ 0 1 MILE



TYPICAL SECTION - DAM

100 0 100 200 FEET



SECTION - SPILLWAY CREST
(LOOKING DOWNSTREAM)

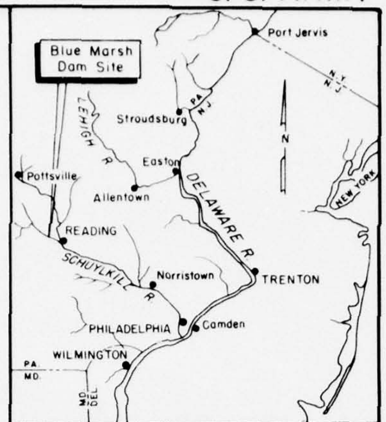
200 0 200 400

LWAY

EET

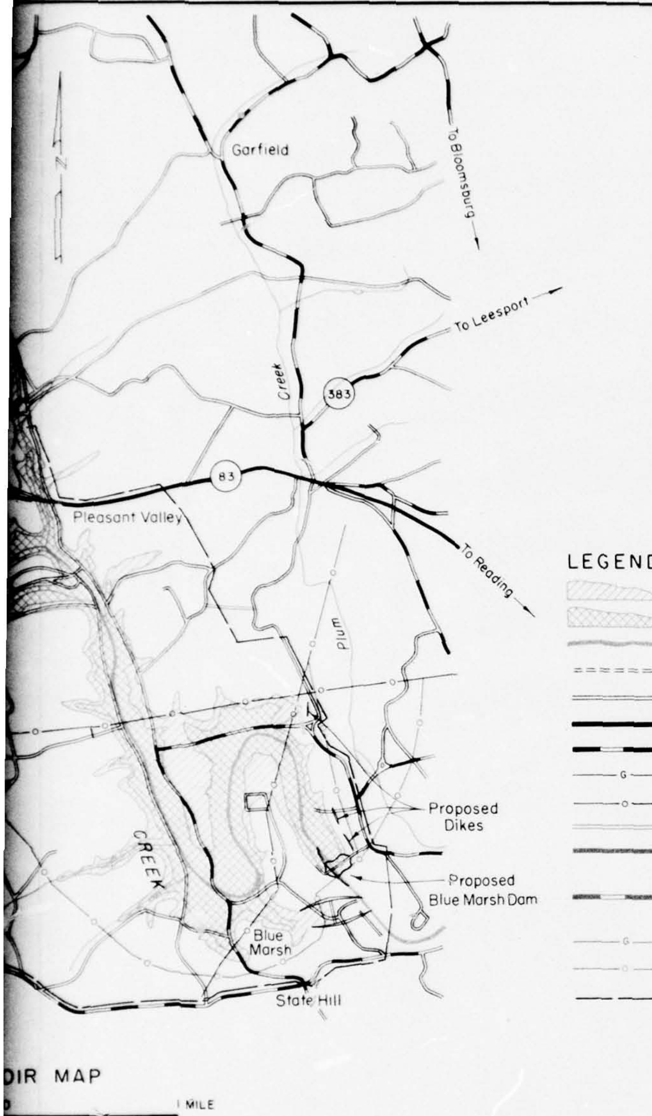
3

U. S. ARMY



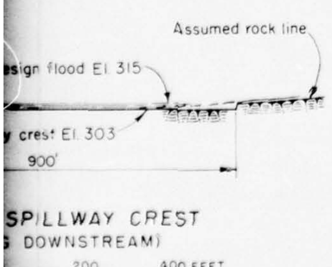
LOCATION MAP

SCALE



LEGEND

	Reservoir at El. 303
	Long Term Storage El. 279
	Existing Stream
	Dirt Road
	Graded Road
	Hard Surface, Heavy Duty Road
	Secondary Hard Surface Road
G	Existing Gas Pipe Line
o	Existing Oil Line
	Proposed Relocated Graded Road
	Proposed Relocated Hard Surface Heavy Duty Road
	Proposed Relocated Secondary Hard Surface Road
G	Proposed Relocated Gas Pipe Line
o	Proposed Relocated Oil Line
	Land Acquisition for Recreation Development



REVIEW REPORT DELAWARE RIVER BASIN

BLUE MARSH PROJECT

In 1 Sheet

Scale as Shown

Corps of Engineers
Philadelphia, Pa.

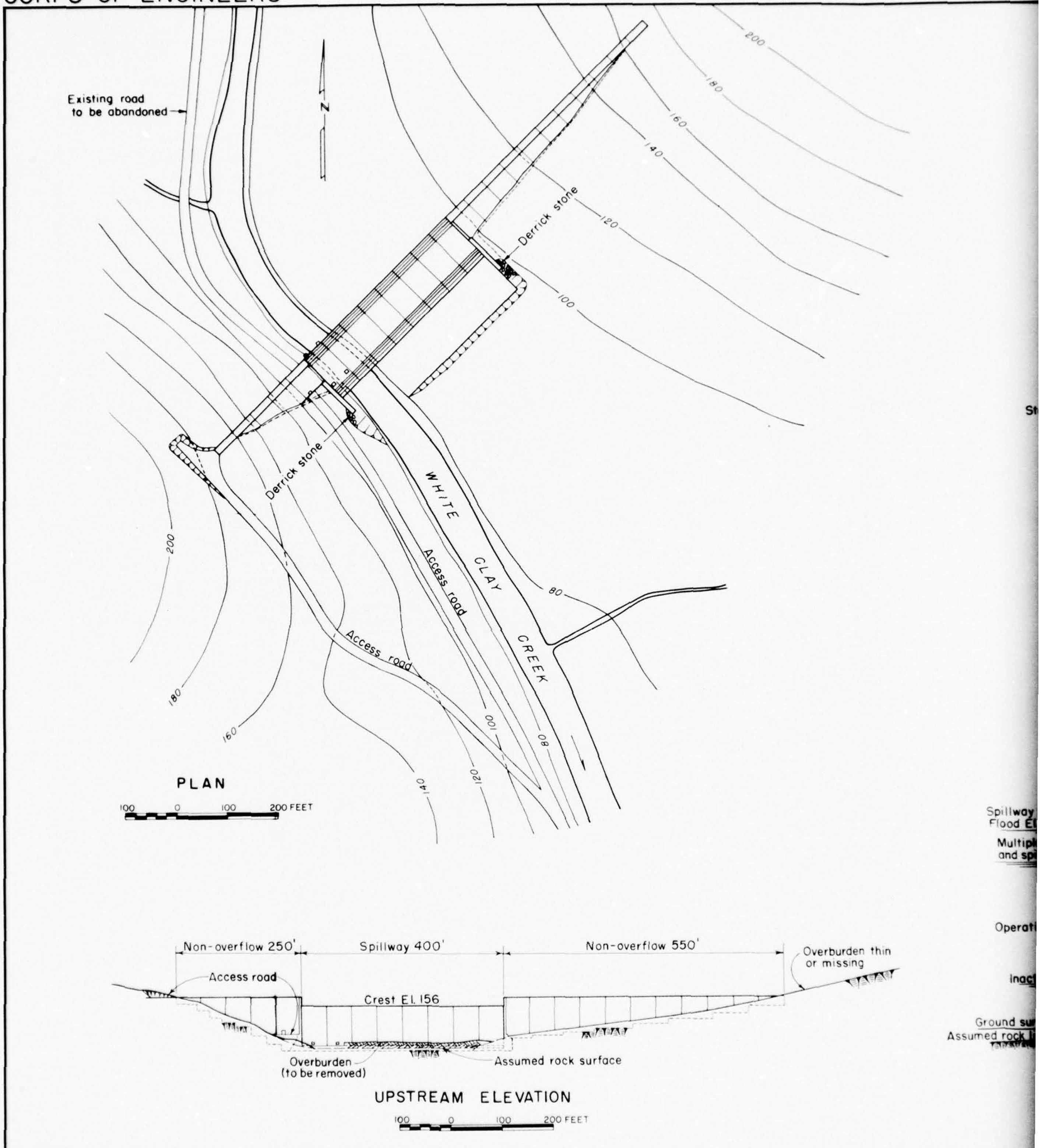
Philadelphia District
June 1960

Drawer No. 228

File No. 29096

PLATE 19

CORPS OF ENGINEERS



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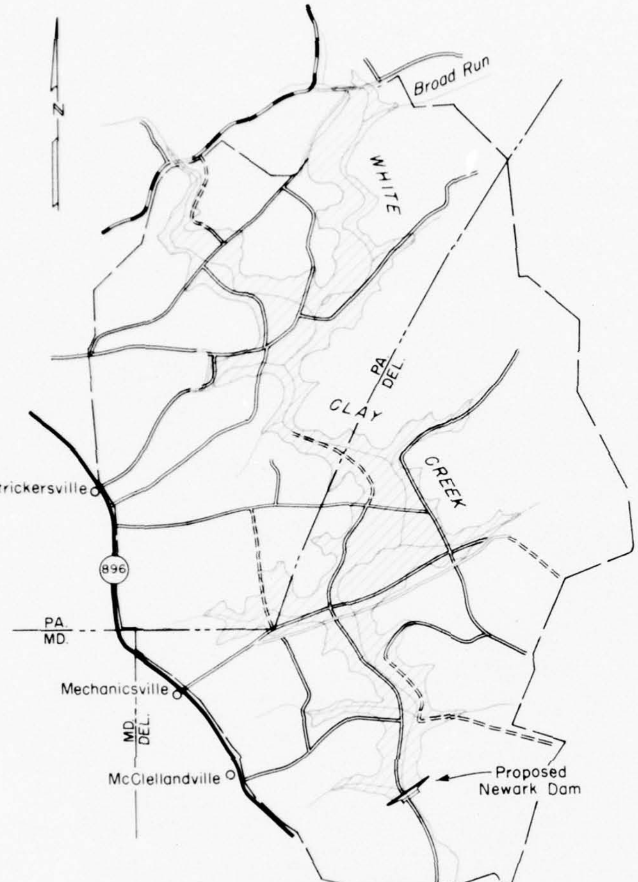
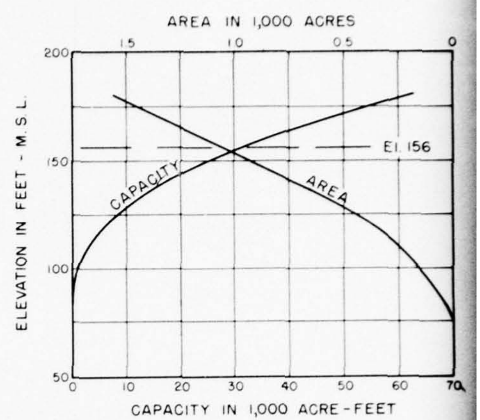
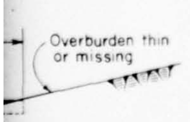


RESERVOIR MAP

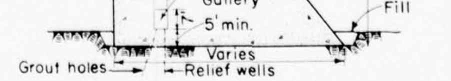


RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface in ac
Multiple - Purpose Pool	156	31,000	1,0



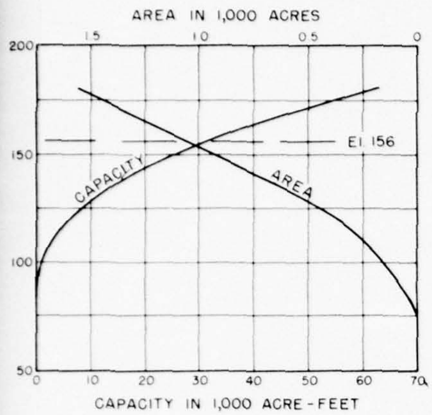
SPILLWAY SECTION



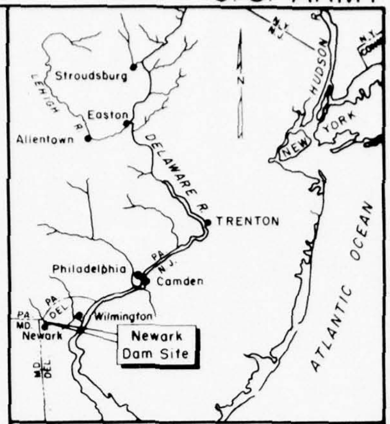
TYPICAL SECTION NON-OVERFLOW DAM

3

U. S. ARMY



RESERVOIR AREA AND CAPACITY CURVES



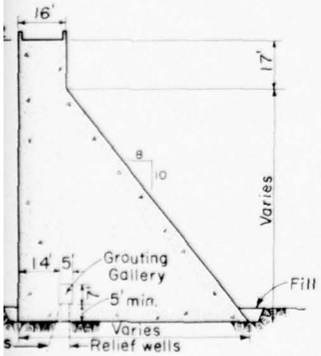
LOCATION MAP

SCALE

LEGEND

- Multiple - Purpose Pool El. 156
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Proposed Relocated Graded Road
- Land Acquisition for Recreation Development

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple - Purpose Pool	156	31,000	1,060



SECTION NON-OVERFLOW DAM

20 0 20 40 FEET

REVIEW REPORT DELAWARE RIVER BASIN

NEWARK PROJECT

In 1 Sheet — Scale as Shown

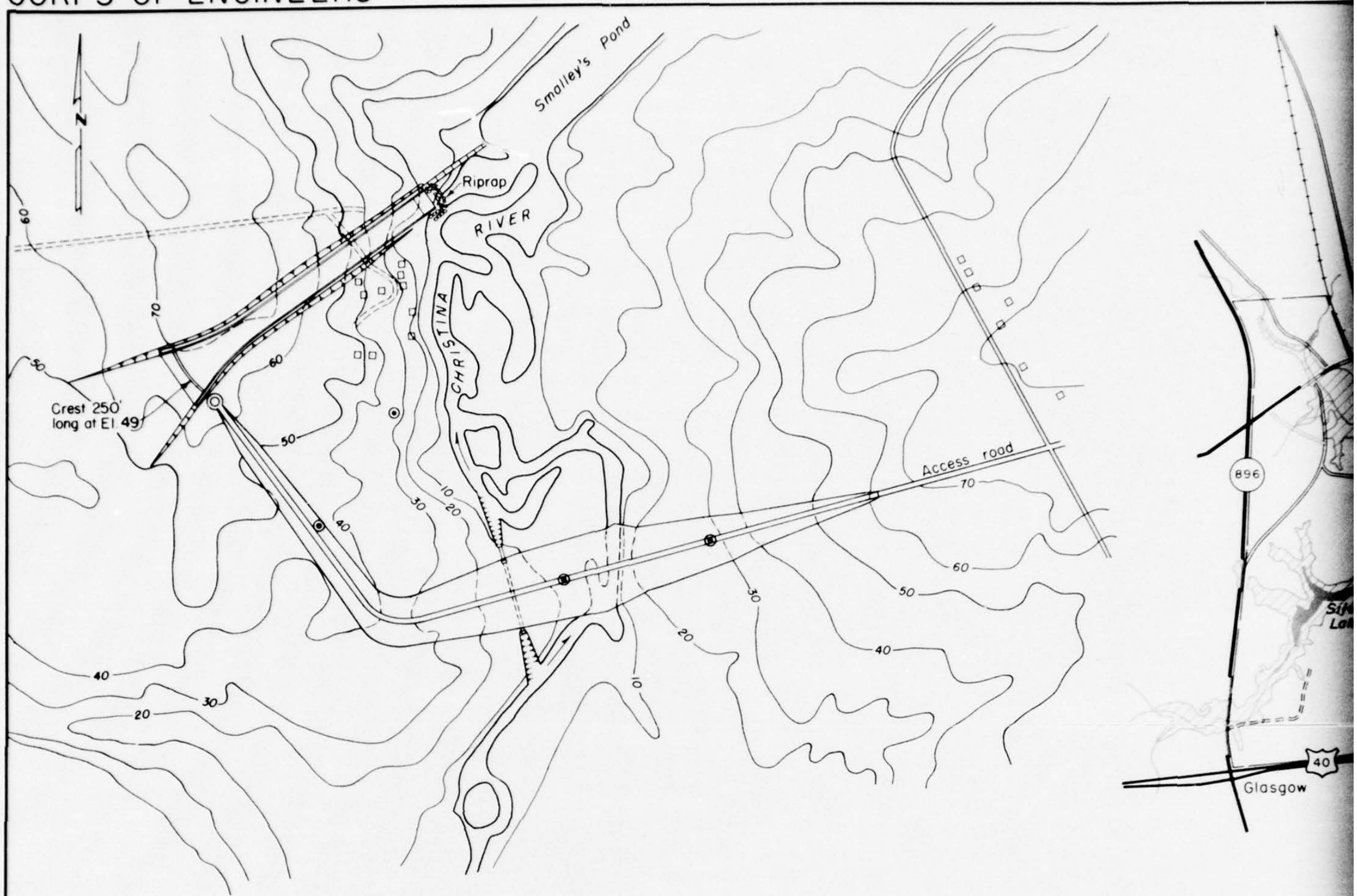
Corps of Engineers
Philadelphia, Pa.

Philadelphia District
June 1960
Revised Oct. 1960

Drawer No. 228 — File No. 29118

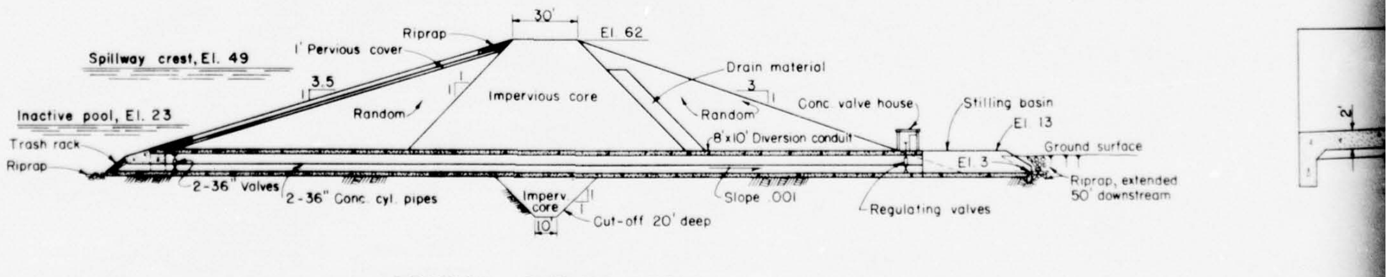
PLATE 20

CORPS OF ENGINEERS



PLAN

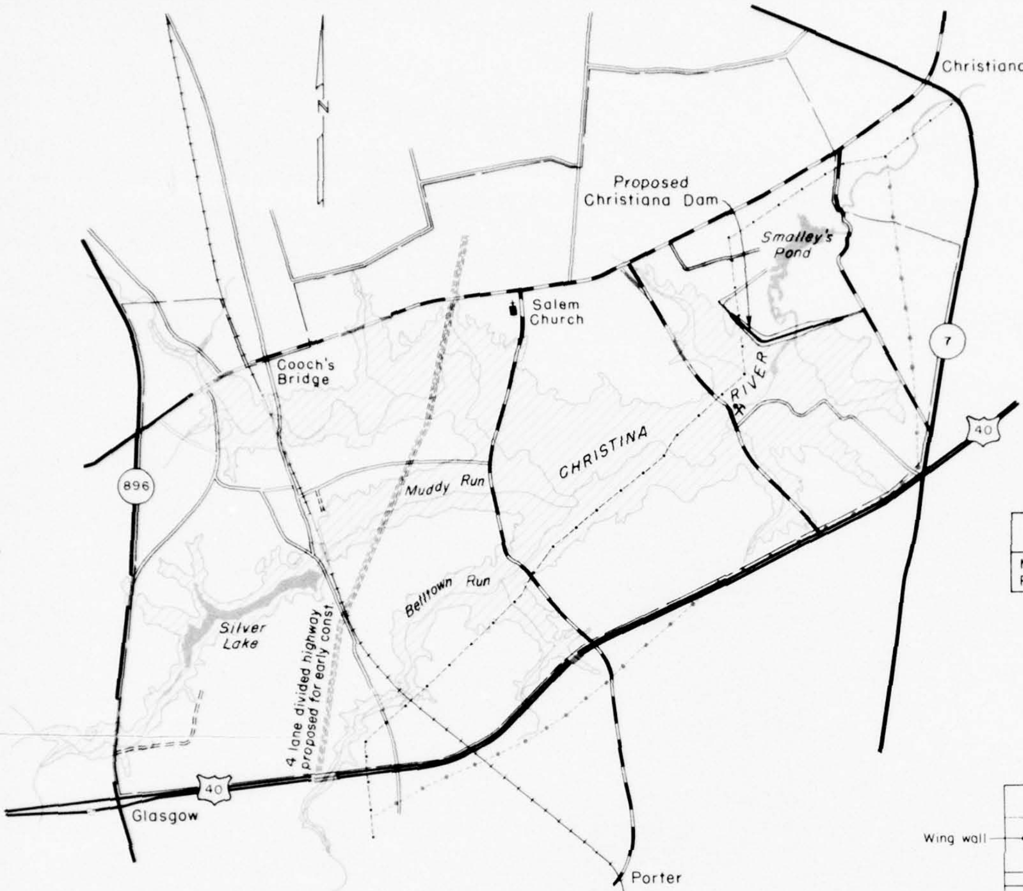
400 0 400 800 FEET



SECTION - OUTLET WORKS

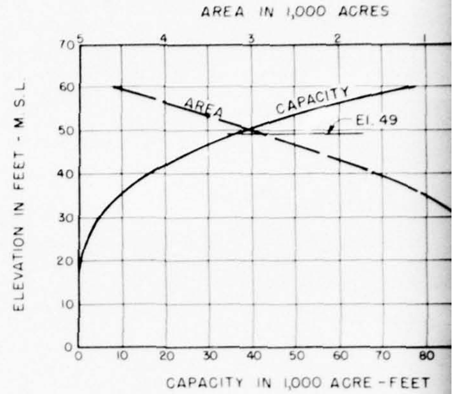
20 0 20 40 60 80 FEET

2



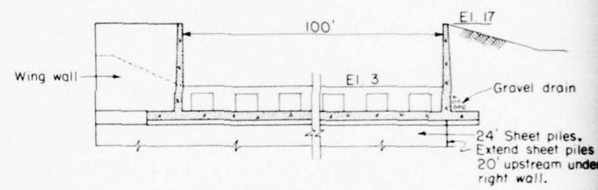
RESERVOIR MAP

1 ½ 0 1 MILE



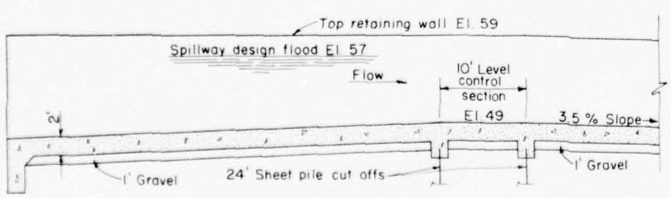
RESERVOIR AREA AND CAPACITY CU

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple-Purpose Pool	49	37,000	2,900



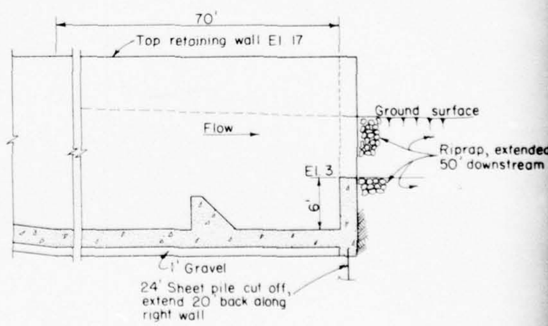
SECTION THRU STILLING BASIN
(LOOKING DOWNSTREAM)

20 0 20 40 FEET



SECTION - SPILLWAY CREST

10 0 10 20 FEET



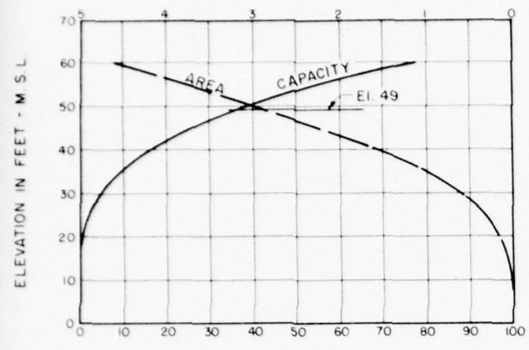
SECTION - STILLING BASIN

10 0 10 20 FEET

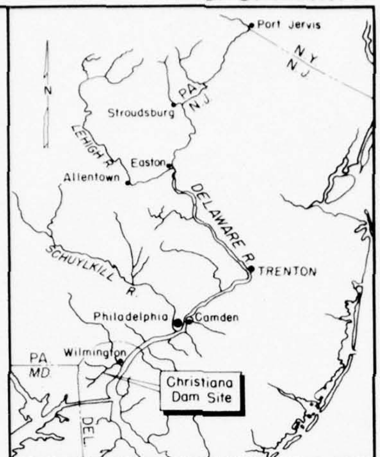
ound surface

Riprap, extended
50' downstream

U. S. ARMY



RESERVOIR AREA AND CAPACITY CURVES



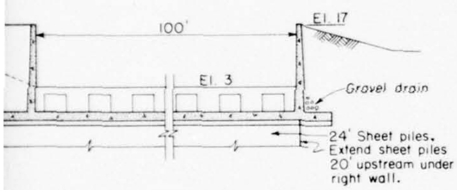
LOCATION MAP

SCALE

CHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
le -Purpose	49	37,000	2,900

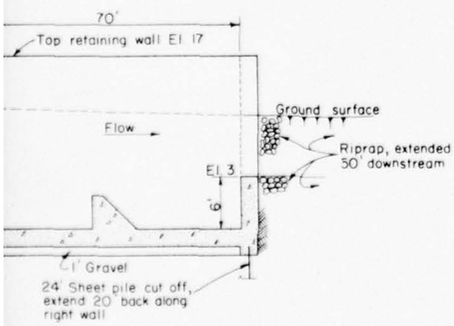
LEGEND

- Multiple-Purpose Pool El. 49
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Railroad
- Existing Power Line
- Proposed Relocated Graded Road
- Proposed Raised Hard Surface Heavy Duty Road
- Proposed Raised Secondary Hard Surface Road
- Proposed Raised Railroad
- Proposed Relocated Power Line
- Land Acquisition for Recreation Development
- Drill Hole
- Gravel Pit



SECTION THRU STILLING BASIN
(LOOKING DOWNSTREAM)

20 0 20 40 FEET



CTION - STILLING BASIN

10 0 10 20 FEET

REVIEW REPORT DELAWARE RIVER BASIN

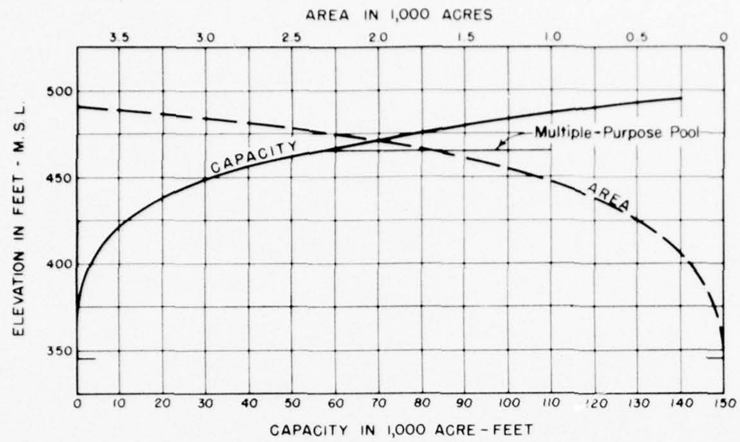
CHRISTIANA PROJECT

In 1 Sheet | Scales as Shown

Corps of Engineers, Philadelphia, Pa. | Philadelphia District, June 1960

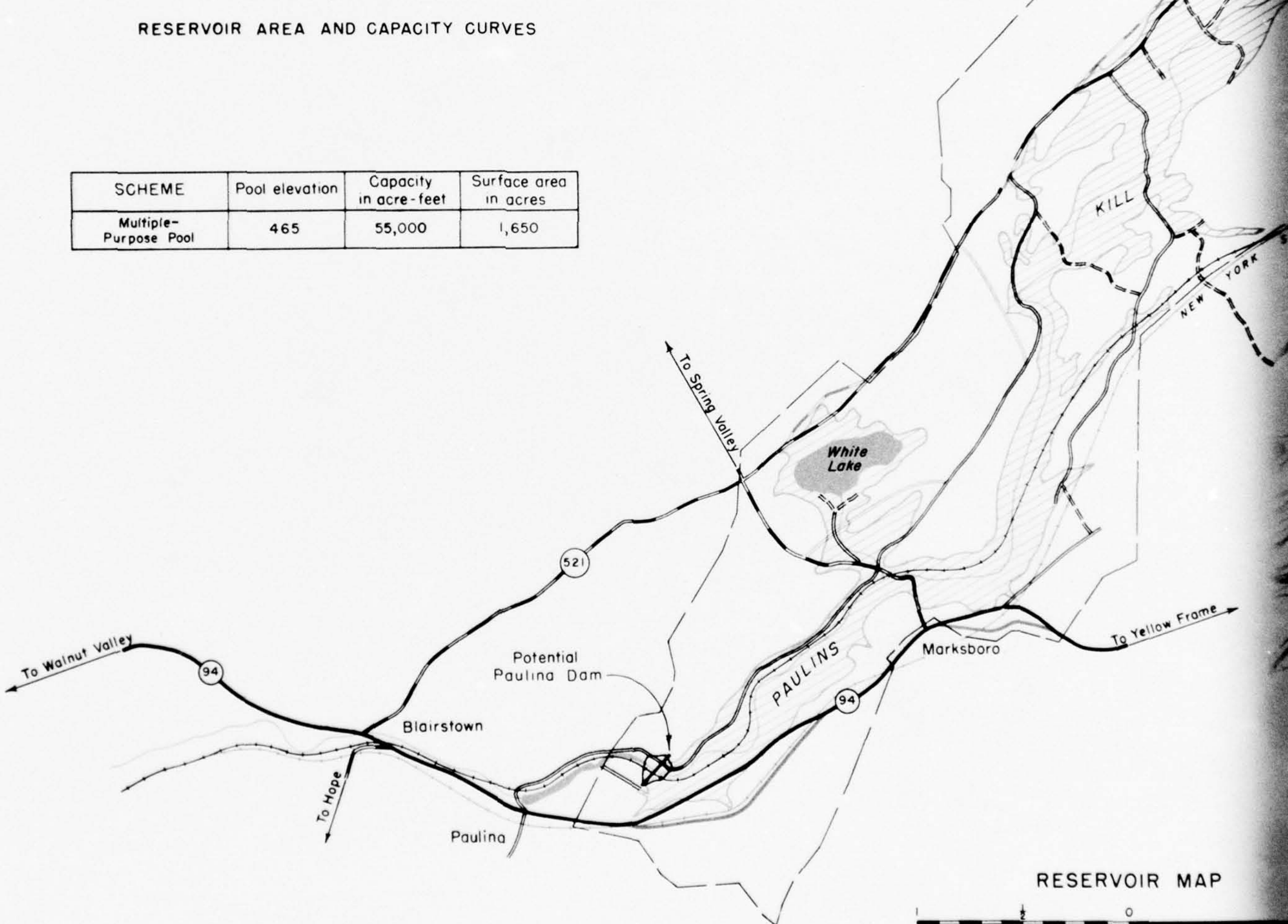
Drawer No. 228 | File No. 29121

CORPS OF ENGINEERS



RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple-Purpose Pool	465	55,000	1,650



RESERVOIR MAP

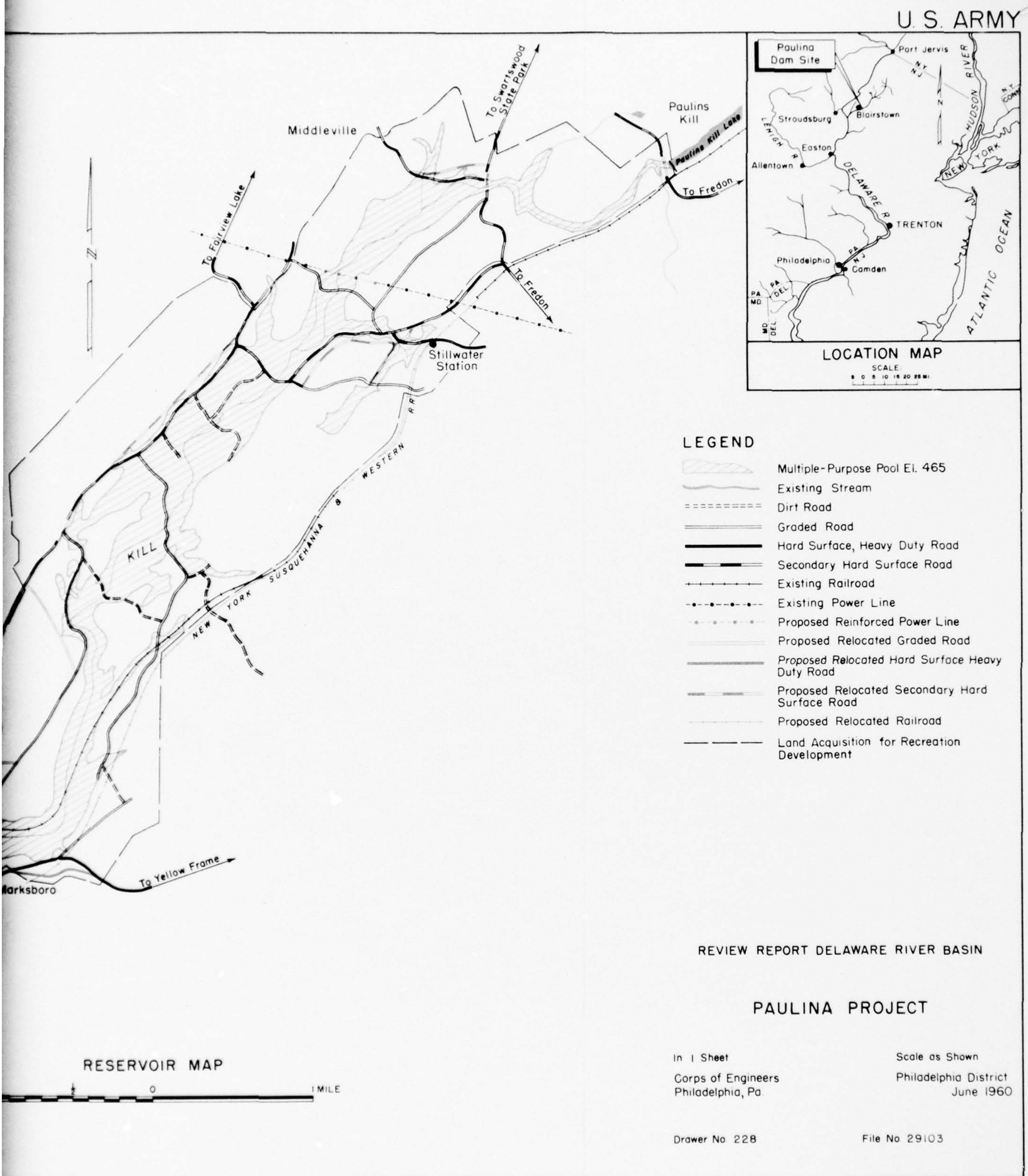

U. S. ARMY
Paulina Dam Site
Port Jervis
N.Y.
N.J.
HUDSON RIVER
Stroudsburg
Blairstown
LEHIGH R.
Easton
Allentown
DELAWARE R.
NEW YORK
TRENTON
ATLANTIC OCEAN
Philadelphia
Camden
PA
N.J.
PA
DEL
MD
LOCATION MAP
SCALE
Middleville
To Swartswood State Park
Paulins Kill
Paulins Kill Lake
To Fredon
To Fairview Lake
To Fredon
Stillwater Station
KILL
NEW YORK SUSQUEHANNA & WESTERN R.R.
To Yellow Frame
Marksboro
LEGEND
Multiple-Purpose Pool El. 465
Existing Stream
Dirt Road
Graded Road
Hard Surface, Heavy Duty Road
Secondary Hard Surface Road
Existing Railroad
Existing Power Line
Proposed Reinforced Power Line
Proposed Relocated Graded Road
Proposed Relocated Hard Surface Heavy Duty Road
Proposed Relocated Secondary Hard Surface Road
Proposed Relocated Railroad
Land Acquisition for Recreation Development
RESERVOIR MAP
0
1 MILE
REVIEW REPORT DELAWARE RIVER BASIN
PAULINA PROJECT
In 1 Sheet
Scale as Shown
Corps of Engineers
Philadelphia, Pa.
Philadelphia District
June 1960
Drawer No. 228
File No. 29103

PLATE 22

CORPS OF ENGINEERS

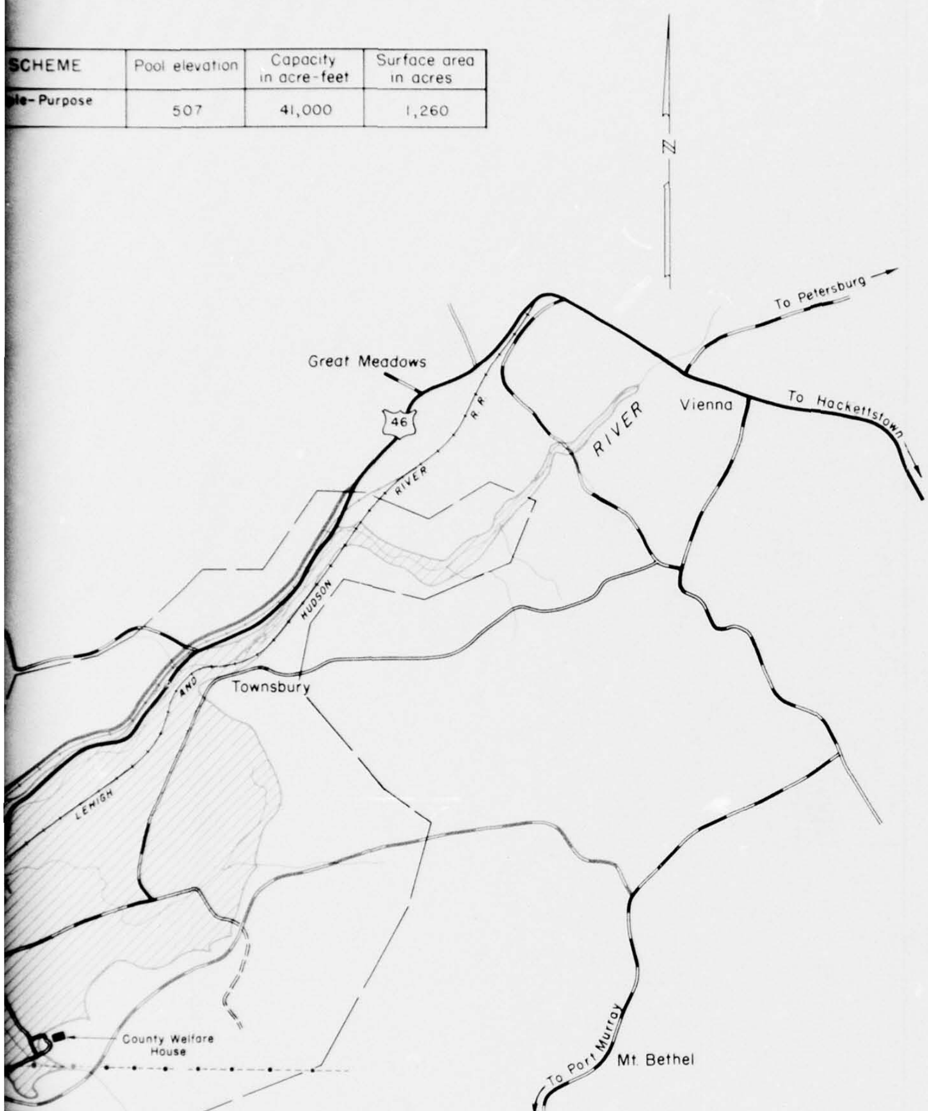
RESERVOIR AREA AND CAPACITY CURVES

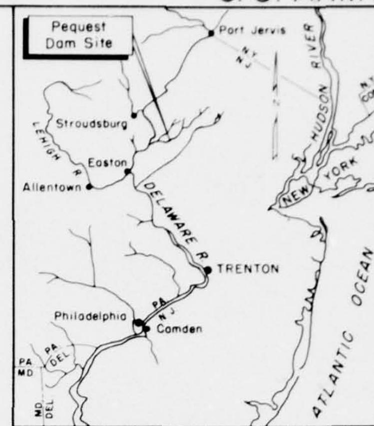
SCHEME	Pool elevation	Capacity in acre-feet
Multiple-Purpose Pool	507	41,000

2

U. S. ARMY

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
ple-Purpose	507	41,000	1,260





LOCATION MAP

SCALE

LEGEND

- Multiple-Purpose Pool Elevation 507
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Railroad
- Existing Power Line
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Railroad
- Proposed Reinforced Power Line
- Land Acquisition for Recreation Development

RESERVOIR MAP

1 ½ 0 1 MILE

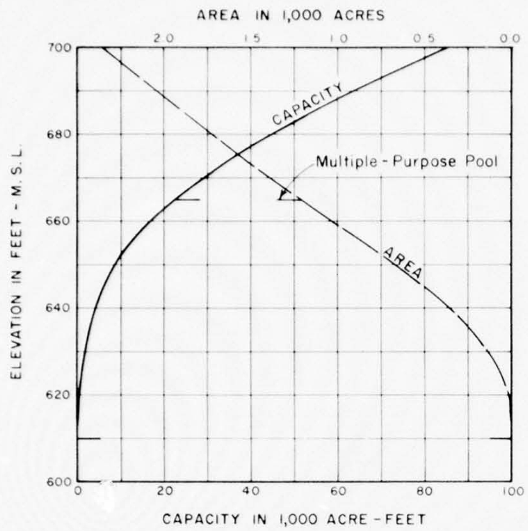
REVIEW REPORT DELAWARE RIVER BASIN

PEQUEST PROJECT

In 1 Sheet — Scale as Shown

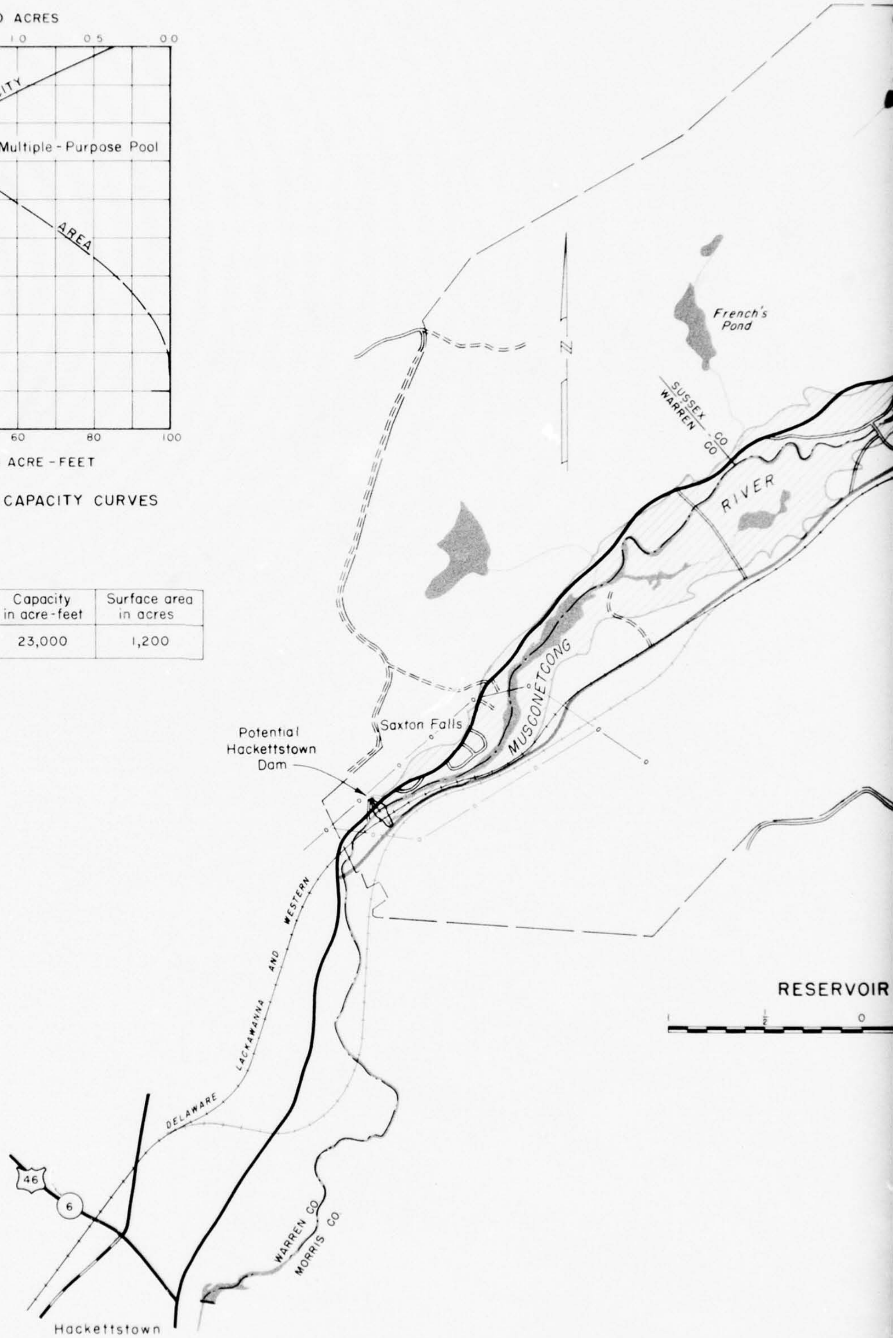
Corps of Engineers, Philadelphia, Pa. — Philadelphia District, June 1960

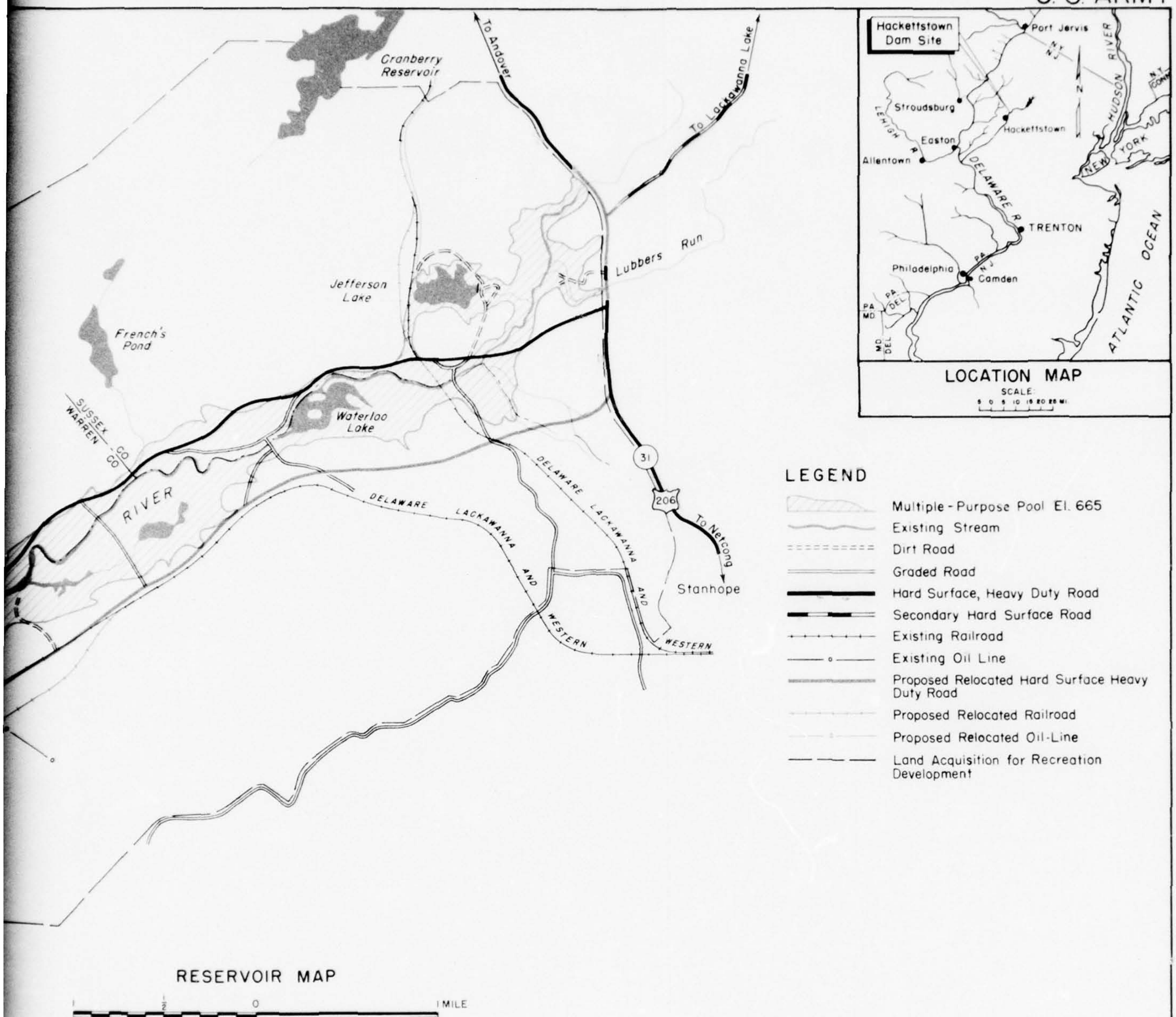
Drawer No. 228 — File No. 29106



RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple - Purpose Pool	665	23,000	1,200





REVIEW REPORT DELAWARE RIVER BASIN

HACKETTSTOWN PROJECT

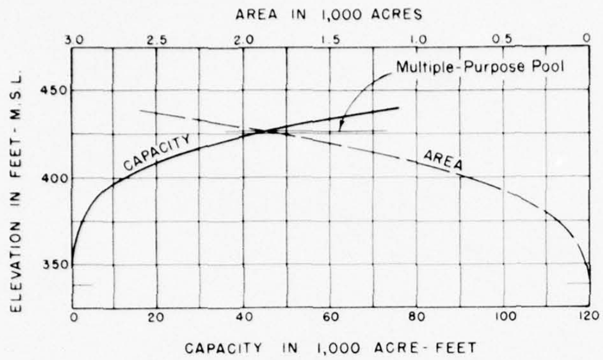
In 1 Sheet | Scale as Shown

Corps of Engineers, Philadelphia, Pa. | Philadelphia District, June 1960

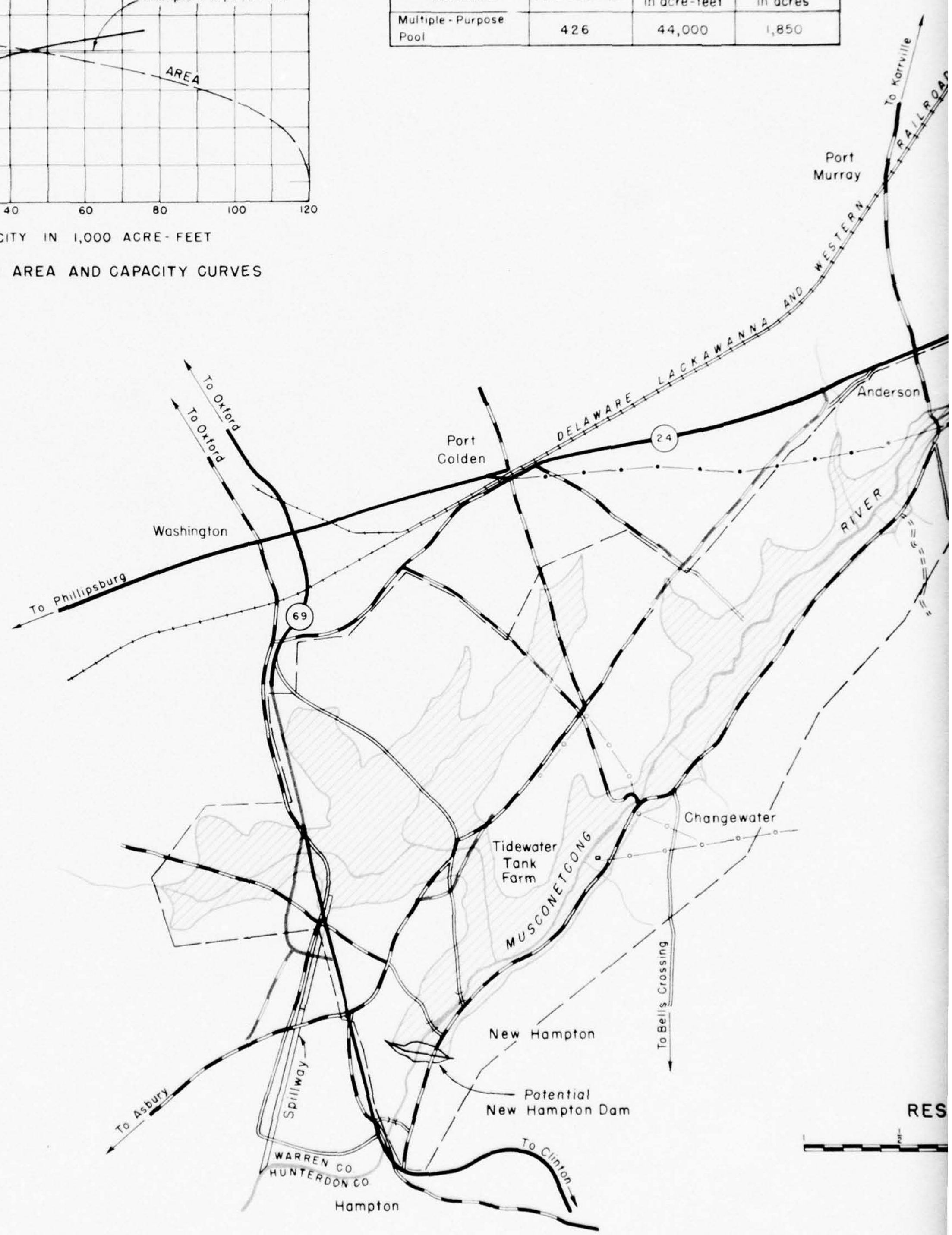
Drawer No. 228 | File No. 29105

CORPS OF ENGINEERS

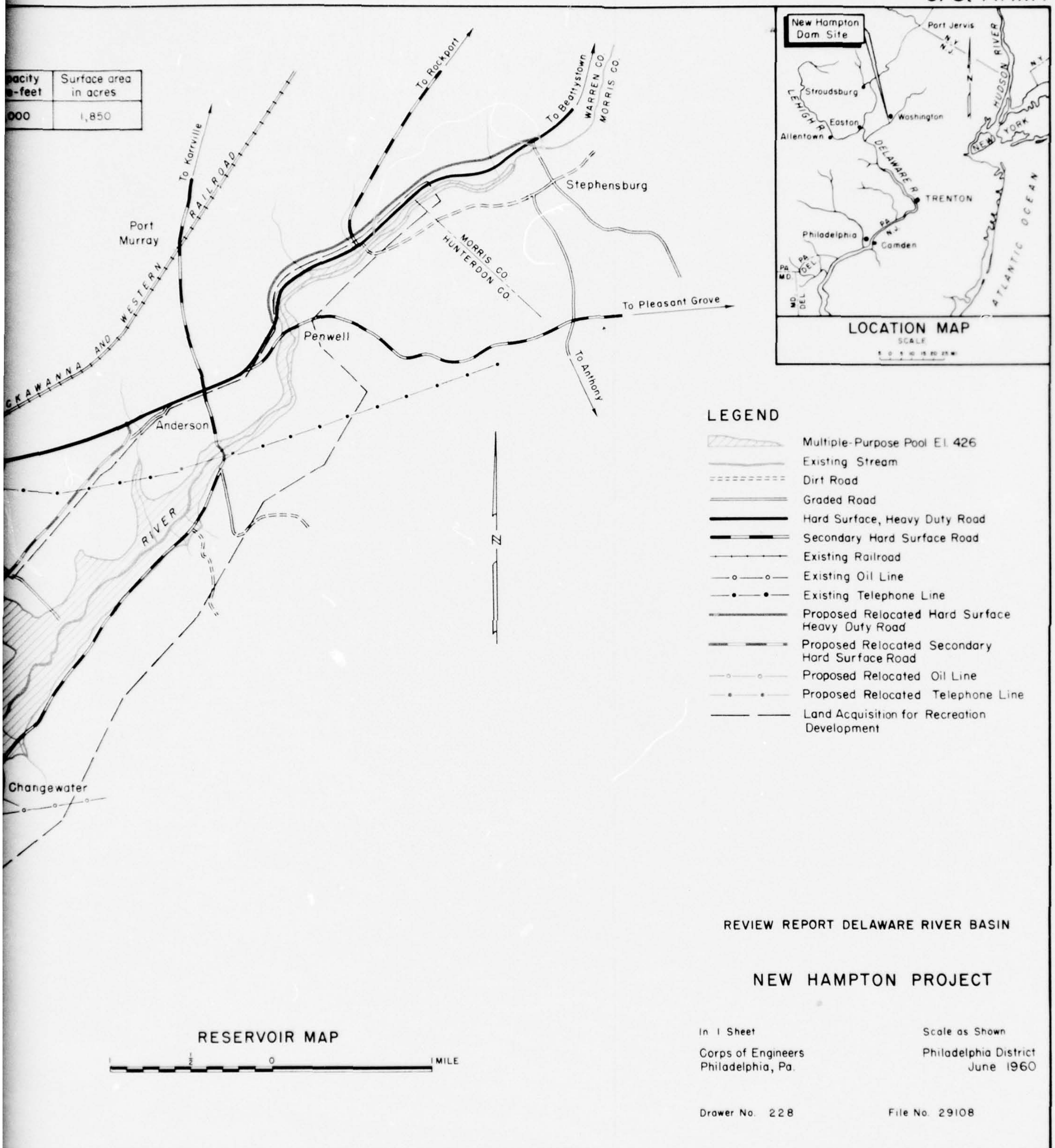
SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple-Purpose Pool	426	44,000	1,850



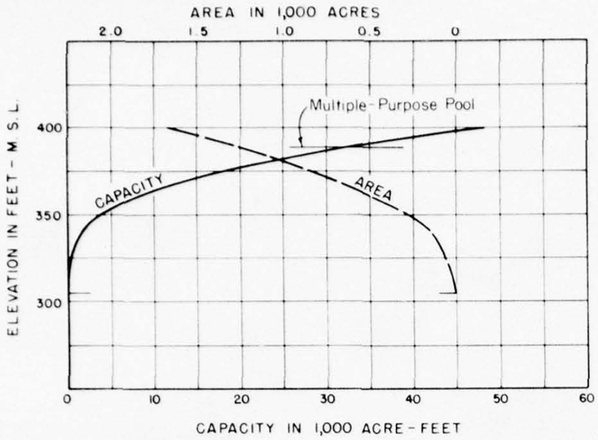
RESERVOIR AREA AND CAPACITY CURVES



U. S. ARMY

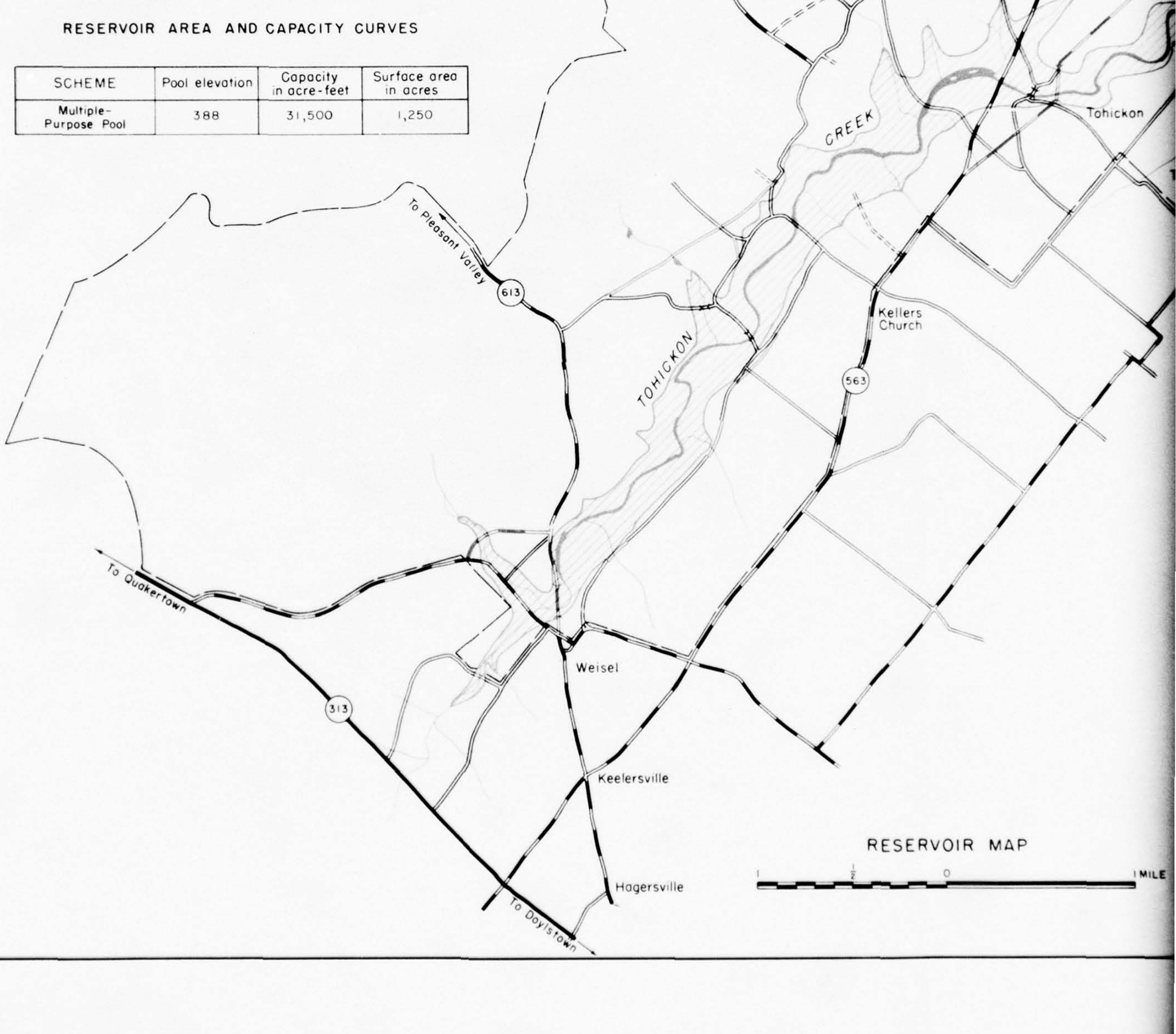


pacity
e-feet
Surface area in acres
000
1,850
To Rockport
To Beattystown
WARREN CO.
MORRIS CO.
To Karrville
Port Murray
LACKAWANNA AND WESTERN RAILROAD
Stephensburg
MORRIS CO.
HUNTERDON CO.
To Pleasant Grove
Penwell
To Anthony
Anderson
RIVER
N
Changewater
New Hampton Dam Site
Port Jervis
N.Y.
N.J.
Stroudsburg
LEHIGH R.
Easton
Washington
Allentown
DELAWARE R.
HUDSON RIVER
NEW YORK
TRENTON
Philadelphia
Camden
PA.
N.J.
PA.
MD.
DEL.
ATLANTIC OCEAN
LOCATION MAP
SCALE
LEGEND
Multiple-Purpose Pool El. 426
Existing Stream
Dirt Road
Graded Road
Hard Surface, Heavy Duty Road
Secondary Hard Surface Road
Existing Railroad
Existing Oil Line
Existing Telephone Line
Proposed Relocated Hard Surface Heavy Duty Road
Proposed Relocated Secondary Hard Surface Road
Proposed Relocated Oil Line
Proposed Relocated Telephone Line
Land Acquisition for Recreation Development
RESERVOIR MAP
1/2
0
1 MILE
REVIEW REPORT DELAWARE RIVER BASIN
NEW HAMPTON PROJECT
In 1 Sheet
Scale as Shown
Corps of Engineers Philadelphia, Pa.
Philadelphia District June 1960
Drawer No. 228
File No. 29108



RESERVOIR AREA AND CAPACITY CURVES

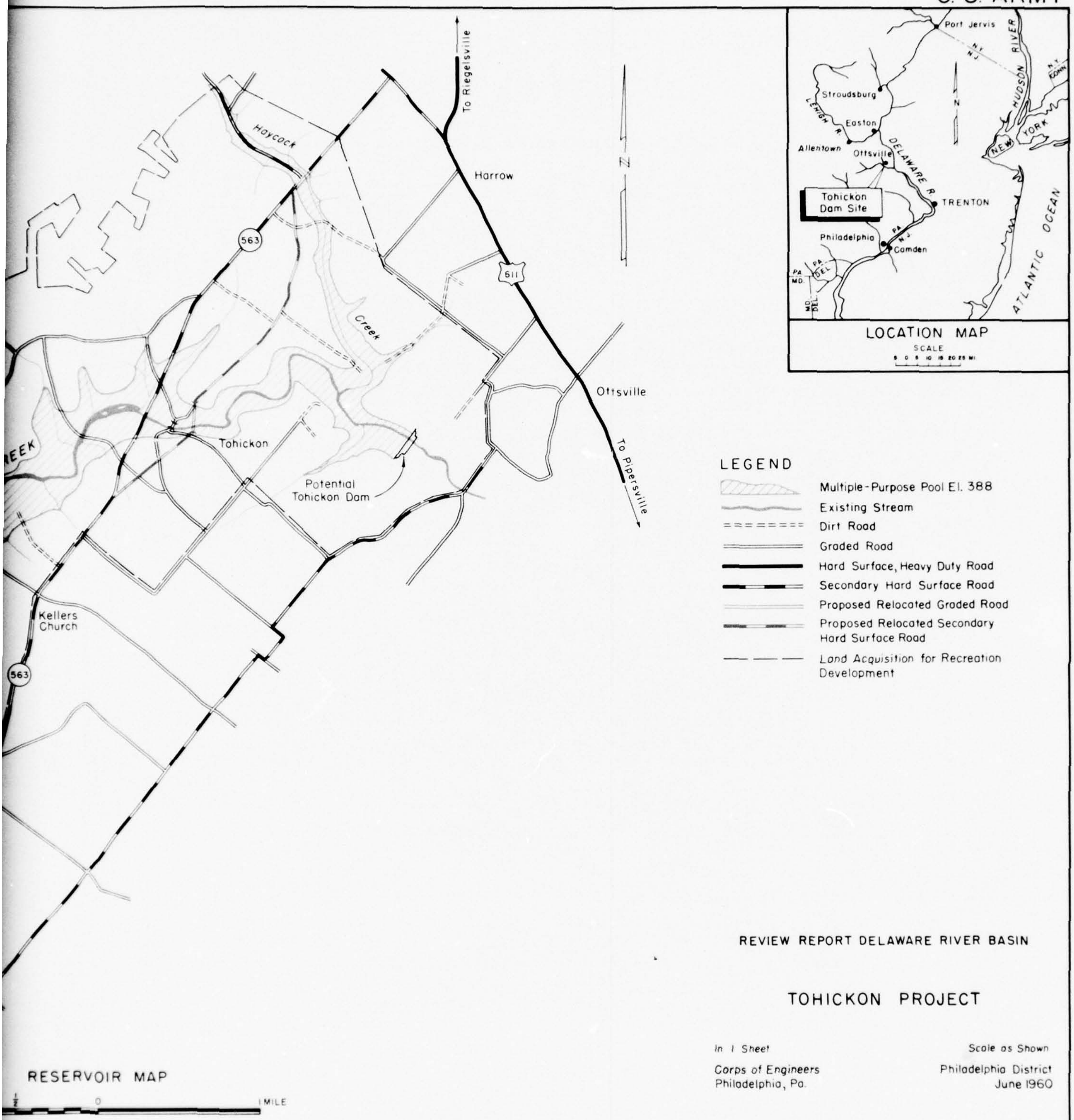
SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple-Purpose Pool	388	31,500	1,250



RESERVOIR MAP

2

U.S. ARMY



REVIEW REPORT DELAWARE RIVER BASIN

TOHICKON PROJECT

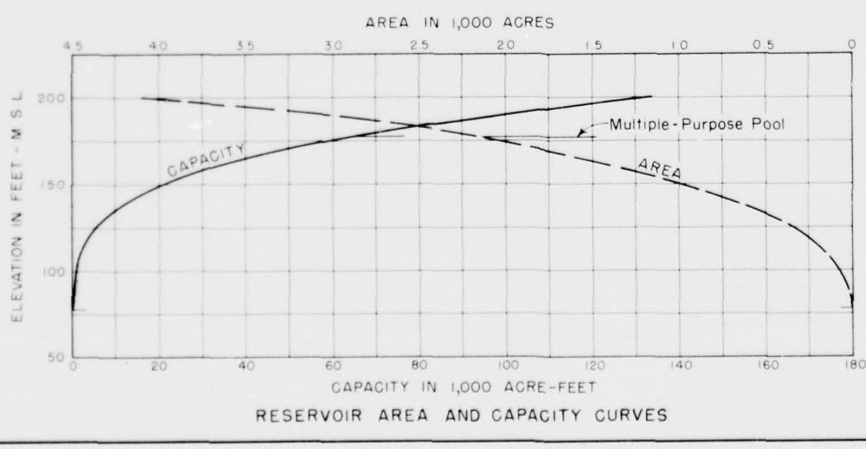
In 1 Sheet — Scale as Shown

Corps of Engineers, Philadelphia, Pa. — Philadelphia District, June 1960

Drawer No. 228 — File No. 29110

CORPS OF ENGINEERS

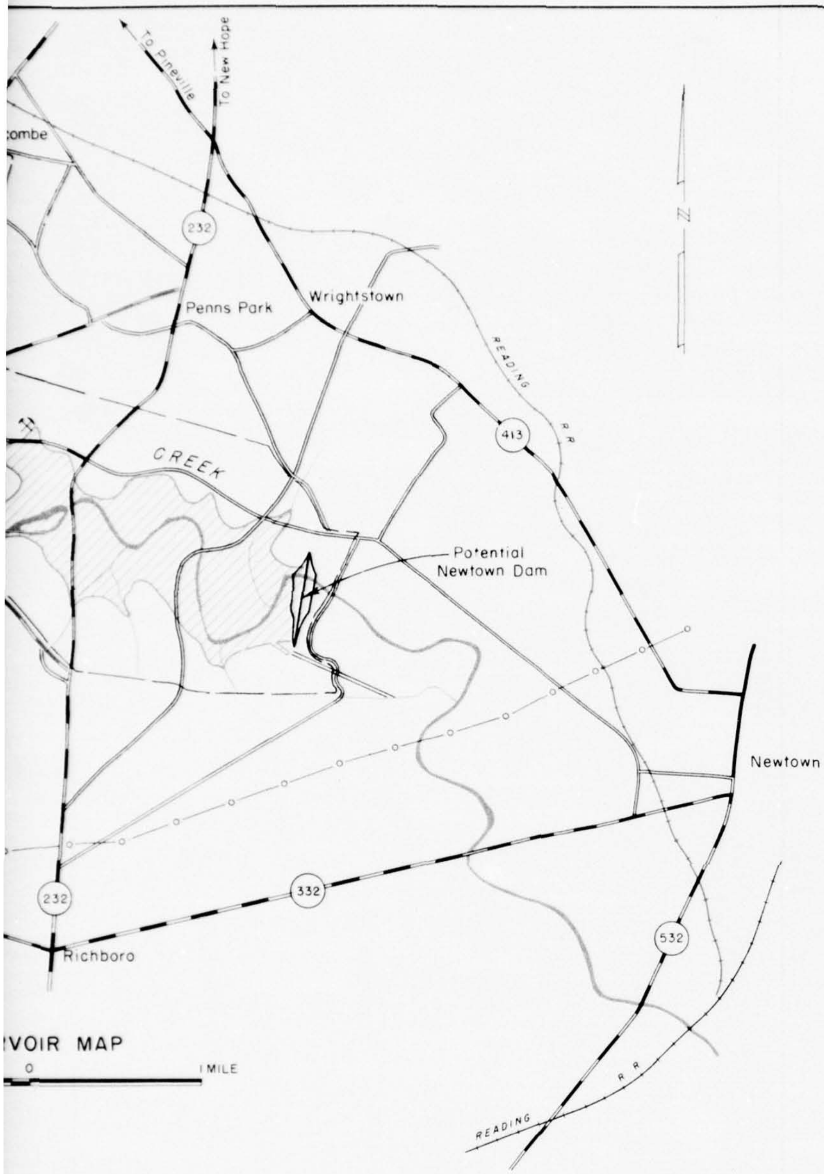
RESERVOIR MAP

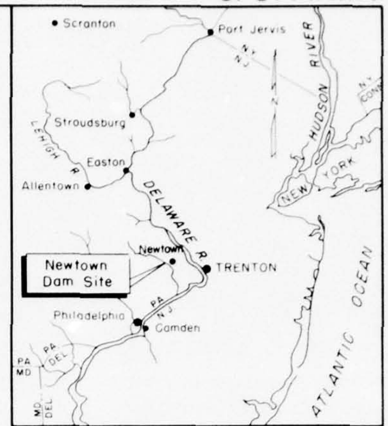


RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Ca in ac
Multiple - Purpose Pool	176	63

U. S. ARMY





LOCATION MAP

SCALE

5 0 5 10 15 20 25 MI

RVOIR MAP

0 1 MILE

LEGEND

- Multiple-Purpose Pool El. 176
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Railroad
- Existing Power Line
- Existing Gas Pipe Line
- Proposed Relocated Graded Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Railroad
- Proposed Relocated Power Line
- Land Acquisition for Recreation Development
- Quarry

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple - Purpose Pool	176	62,000	2,120

REVIEW REPORT DELAWARE RIVER BASIN

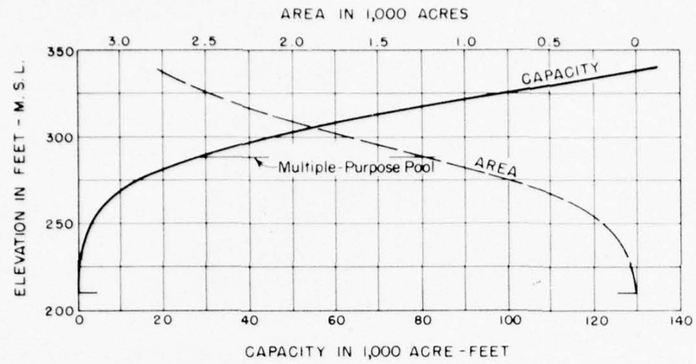
NEWTOWN PROJECT

In 1 Sheet — Scale as Shown

Corps of Engineers
Philadelphia, Pa.

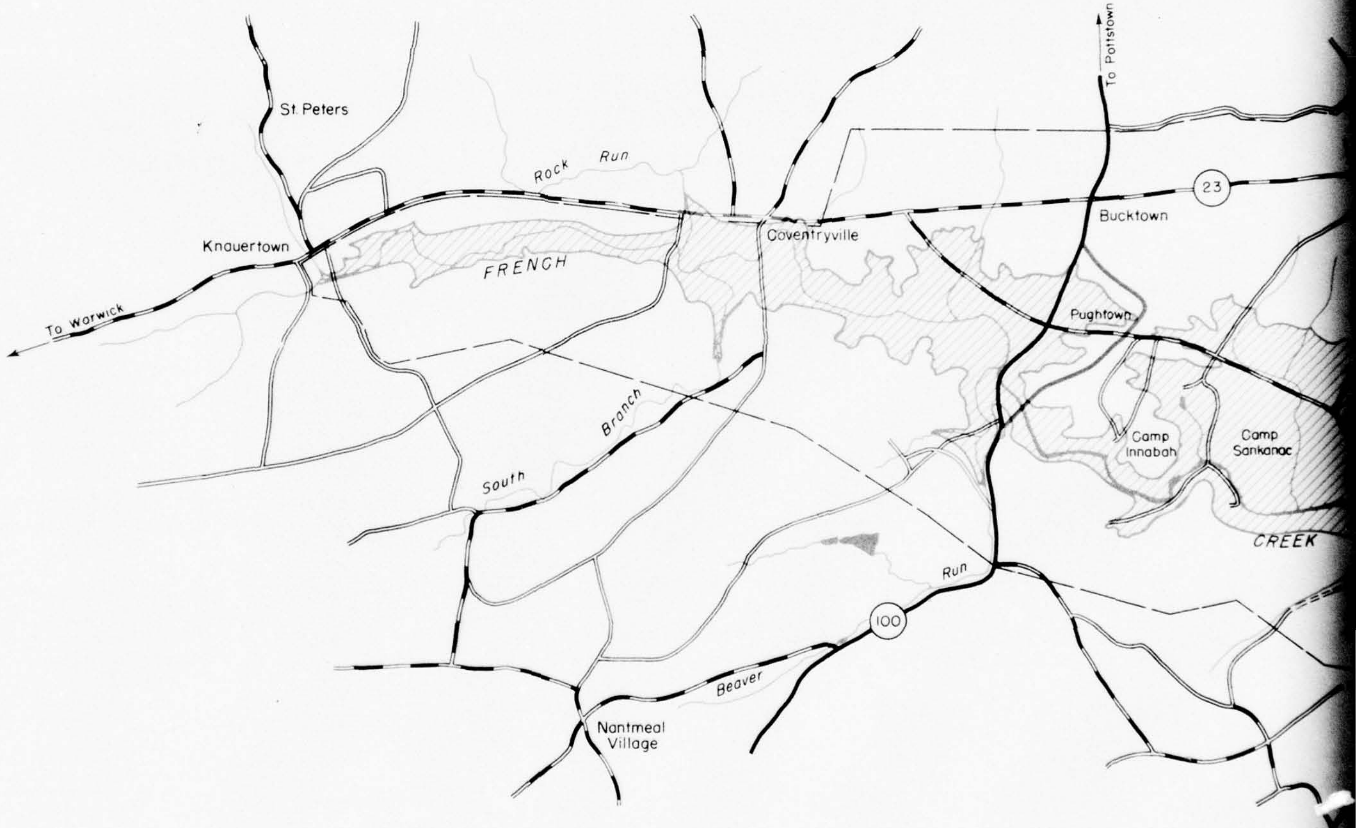
Philadelphia District
June 1960
Revised Oct. 1960

Drawer No. 228 — File No. 29113



RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surfac in ac
Multiple-Purpose Pool	289	27,000	1,25



RESERVOIR MAP

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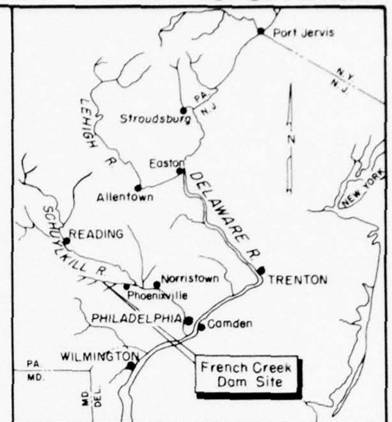
U. S. ARMY

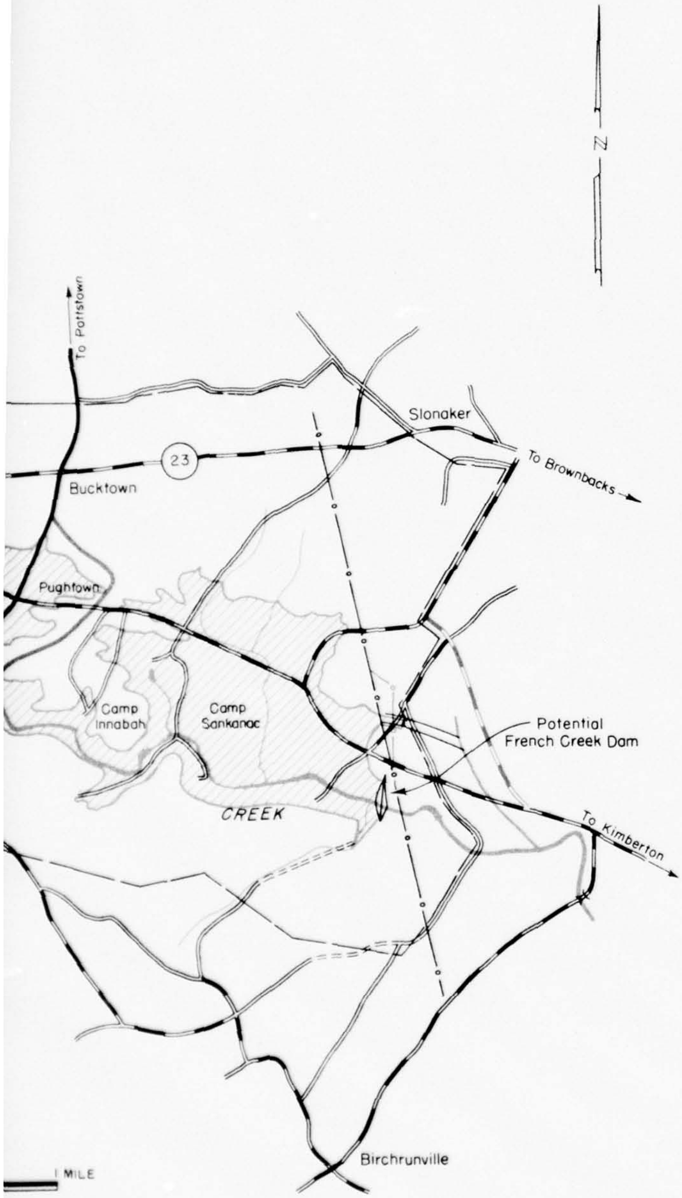
Pool elevation	Capacity in acre-feet	Surface area in acres
289	27,000	1,250



LOCATION MAP

SCALE

5 0 5 10 15 20 25 MI



LEGEND

- Multiple-Purpose Pool El. 289
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Gas Pipe Line
- Proposed Relocated Graded Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Gas Pipe Line
- Land Acquisition for Recreation Development

REVIEW REPORT DELAWARE RIVER BASIN

FRENCH CREEK PROJECT

In 1 Sheet — Scale as Shown

Corps of Engineers Philadelphia, Pa. — Philadelphia District June 1960

Drawer No. 228 — File No. 29114

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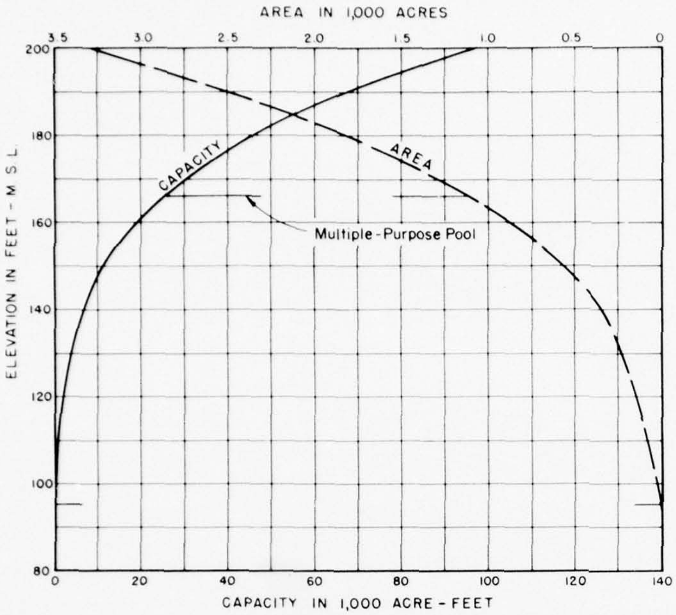
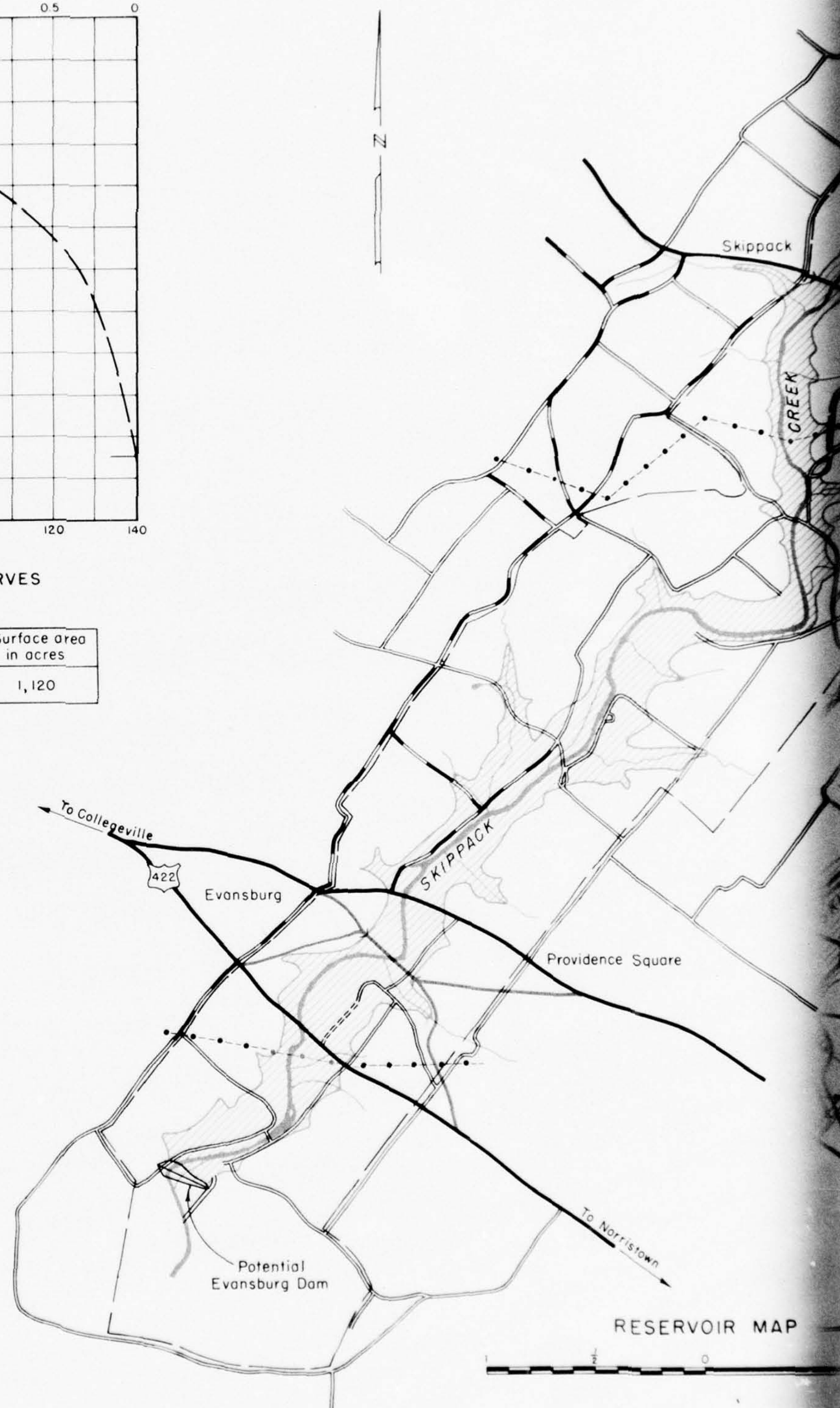


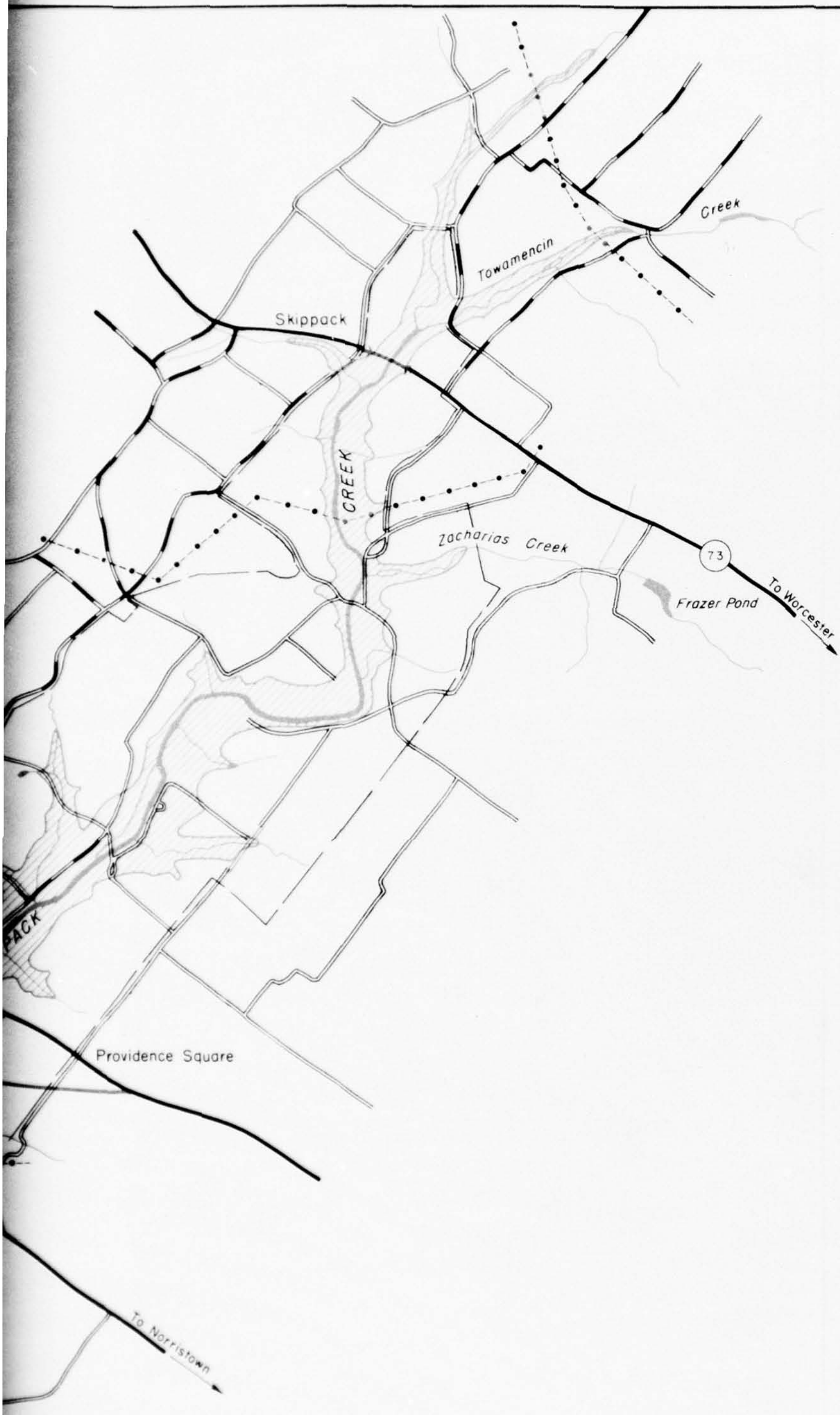
RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple-Purpose Pool	166	25,000	1,120



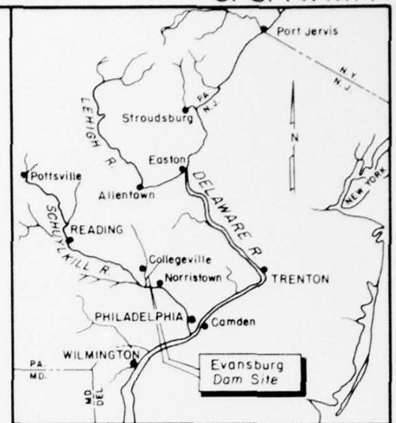
RESERVOIR MAP

U. S. ARMY



RESERVOIR MAP

1 MILE



LOCATION MAP

SCALE

5 0 5 10 15 20 25 MI.

LEGEND

- Multiple-Purpose Pool El. 166
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Power Line
- Proposed Relocated Graded Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Reinforced Power Line
- Land Acquisition for Recreation Development

REVIEW REPORT DELAWARE RIVER BASIN

EVANSBURG PROJECT

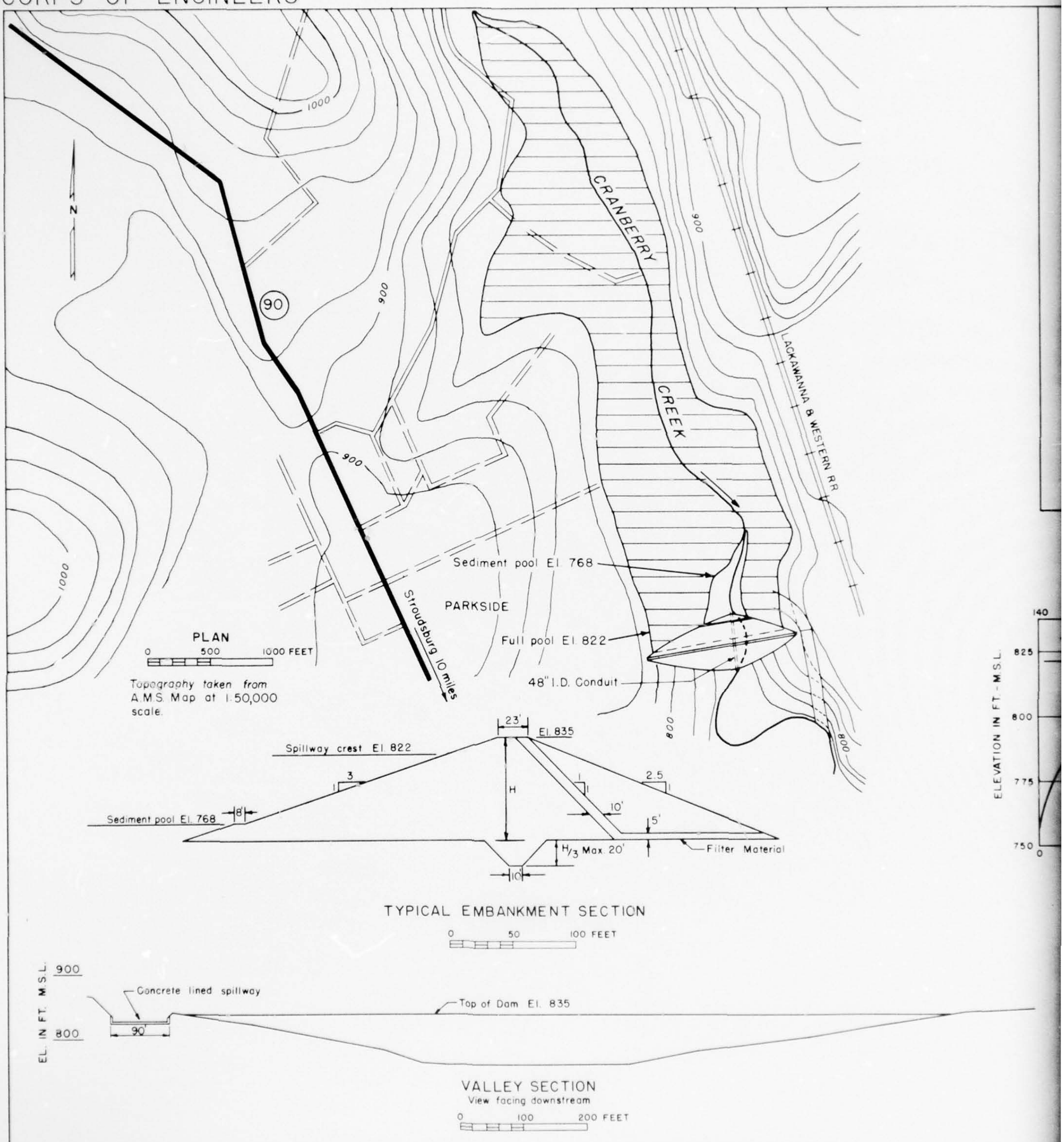
In 1 Sheet — Scale as Shown

Corps of Engineers, Philadelphia, Pa. — Philadelphia District, June 1960

Drawer No. 228 — File No. 29116

PLATE 29

CORPS OF ENGINEERS



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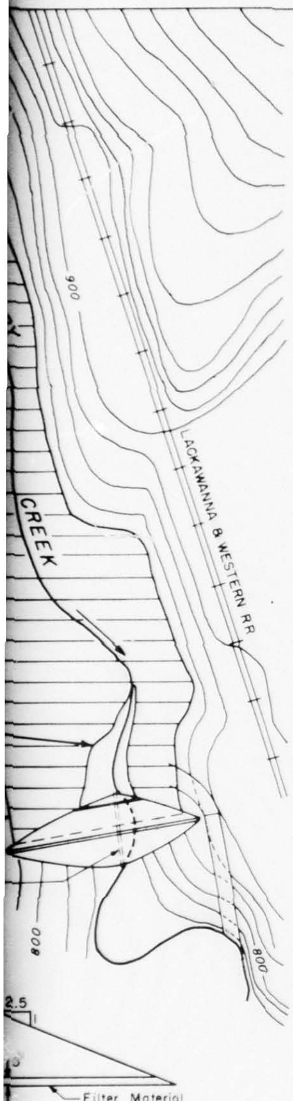
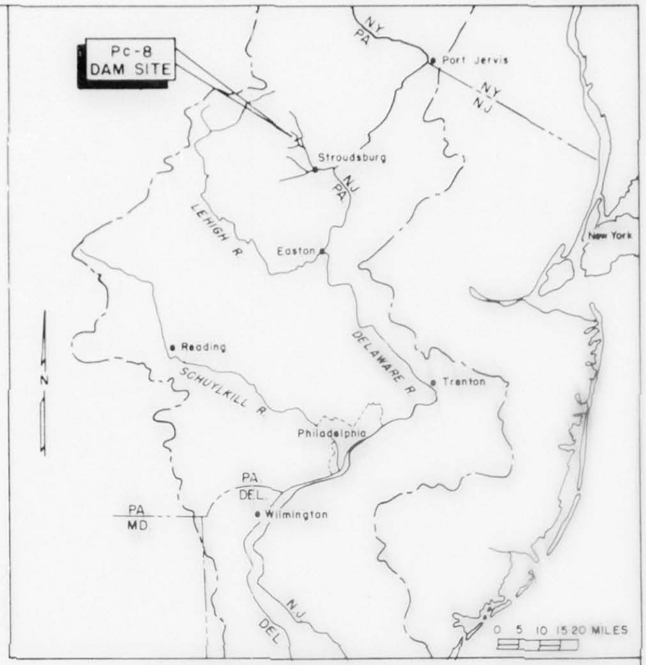
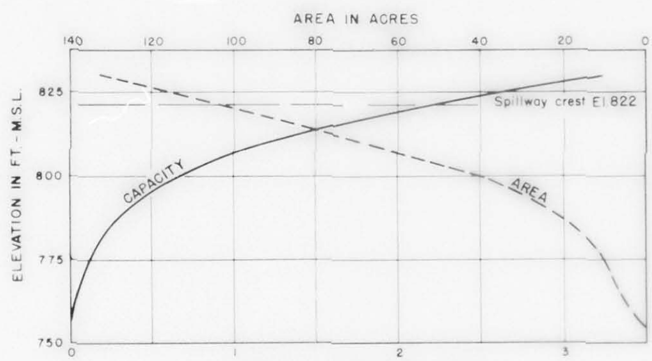




LOCATION MAP



AREA AND CAPACITY CURVES

REVIEW REPORT DELAWARE RIVER BASIN

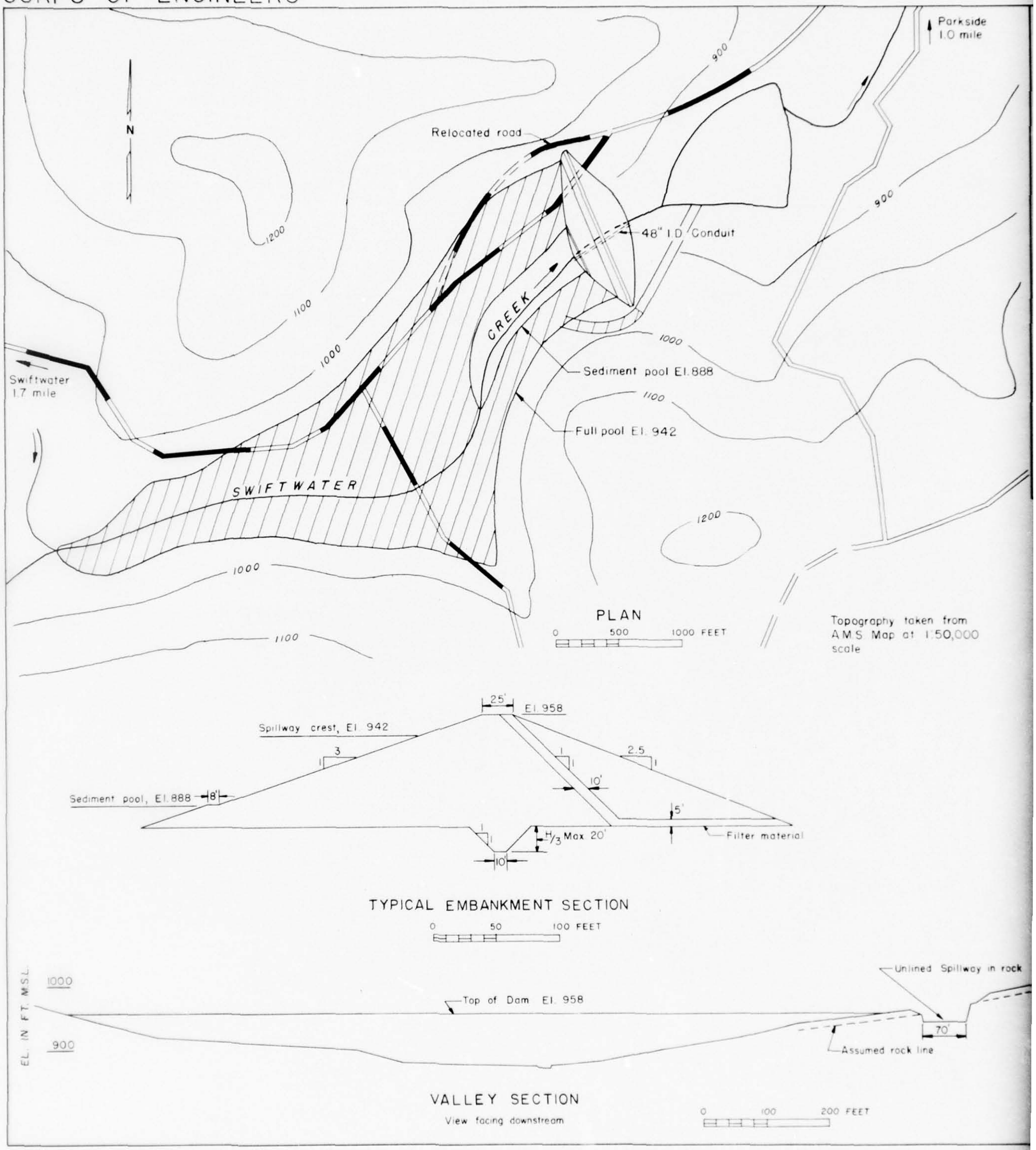
PARKSIDE PROJECT (Pc-8)

Prepared by Joint Work Group
Soil Conservation Service and
Corps of Engineers

Drawer No. 228 File No. 29136

PLATE 30

CORPS OF ENGINEERS



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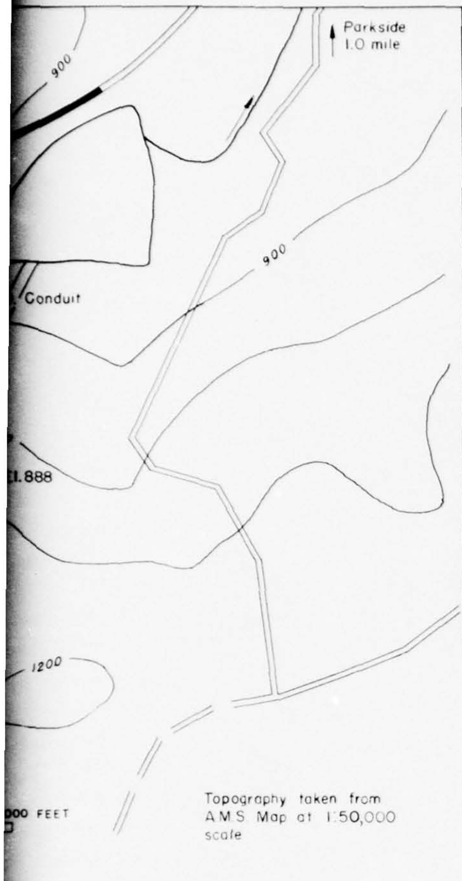
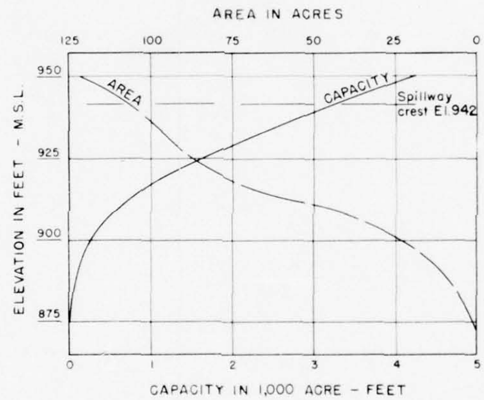
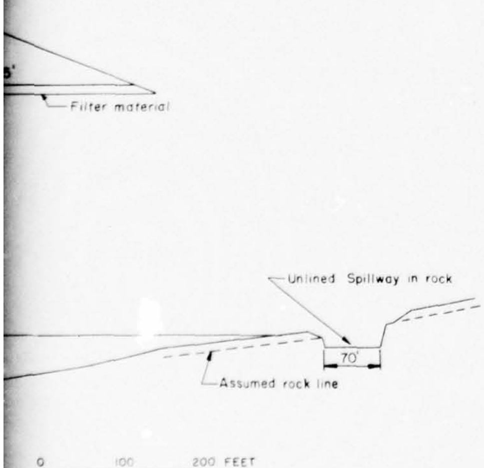


Topography taken from A.M.S. Map at 1:50,000 scale

LOCATION MAP



AREA AND CAPACITY CURVES



REVIEW REPORT DELAWARE RIVER BASIN

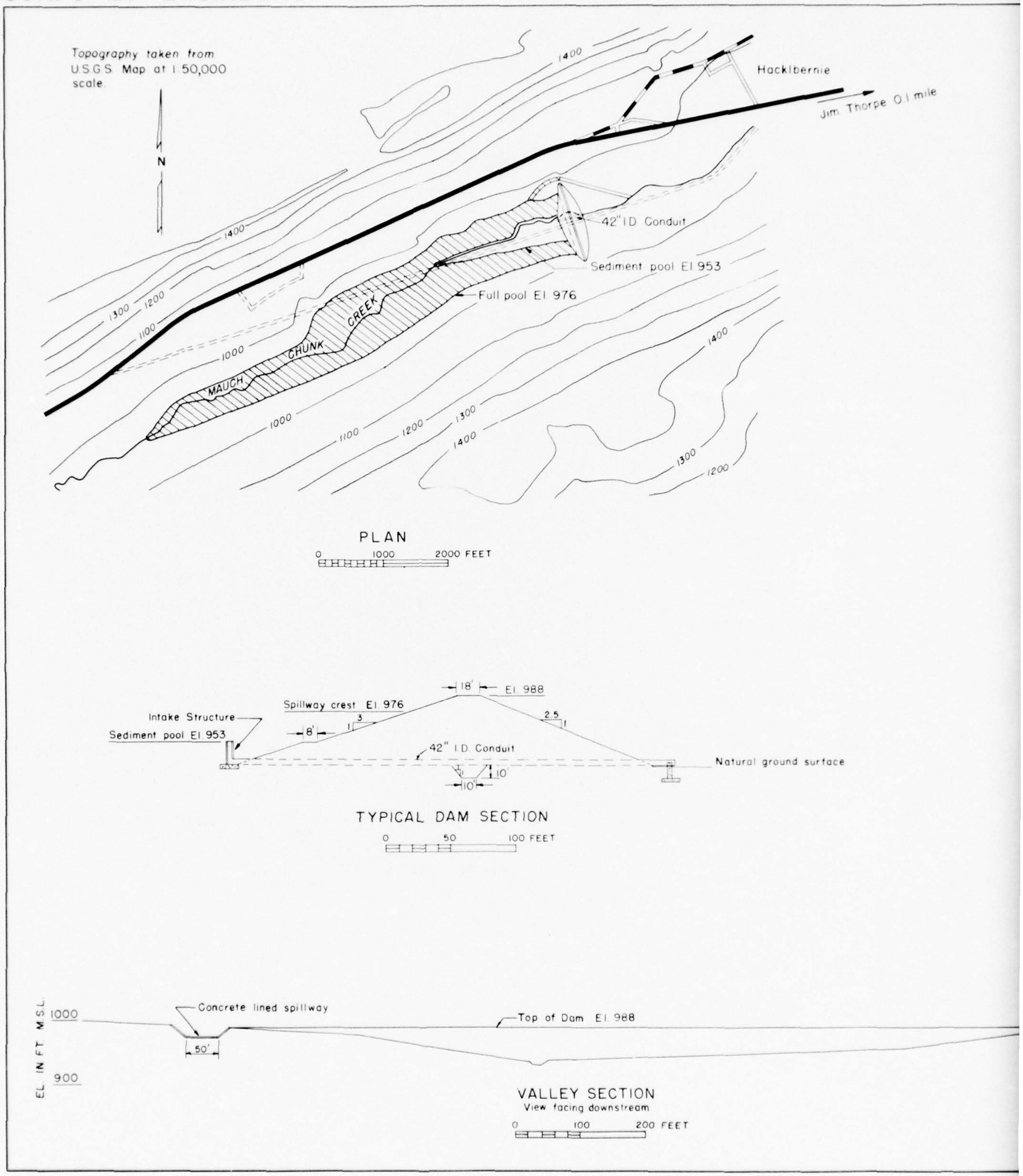
SWIFTWATER PROJECT (Pc-9)

Prepared by Joint Work Group
Soil Conservation Service and
Corps of Engineers

Drawer No. 228 File No. 29134

PLATE 31

CORPS OF ENGINEERS



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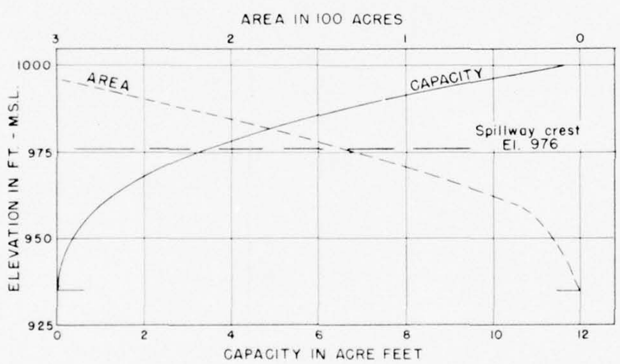
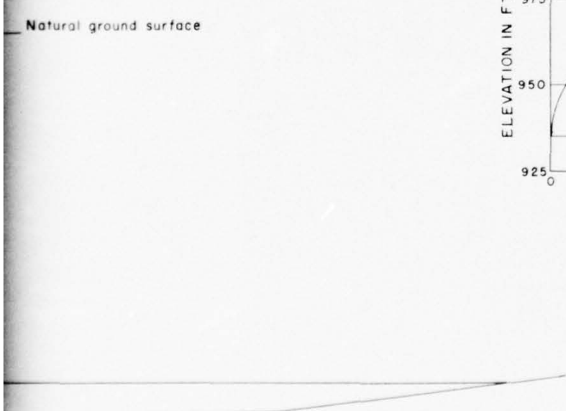
U.S. ARMY

LOCATION MAP



AREA AND CAPACITY CURVES



REVIEW REPORT DELAWARE RIVER BASIN

JIM THORPE PROJECT (Hz-6)

Prepared by Joint Work Group
Soil Conservation Service and
Corps of Engineers

Drawer No. 228 File No. 29135

ATTACHMENT A

TO

REPORT ON THE COMPREHENSIVE

SURVEY OF THE WATER RESOURCES

OF THE DELAWARE RIVER BASIN

INFORMATION CALLED FOR BY
SENATE RESOLUTION 148
85th CONGRESS, 1st SESSION
ADOPTED 28 JANUARY 1958

ATTACHMENT A

CONTENTS

ATTACHMENT A

ADDITIONAL INFORMATION ON RECOMMENDED PROJECTS CALLED FOR IN SENATE RESOLUTION 148, 85TH CONGRESS, FIRST SESSION, ADOPTED 28 JANUARY 1958.

1. GENERAL INFORMATION RELATIVE TO PROJECTS RECOMMENDED IN THE PLAN OF DEVELOPMENT. The 19 major control projects in the recommended plan of development were selected from successive determinations by discrete screenings applied to 193 potential major dam sites inventoried in the basin. Further evaluations applied to these projects assured their maximized net returns. These projects are scheduled for varying degrees of development. The first group of eleven projects would be developed for multiple-purposes prior to the year 2010. The second group of eight projects would be initially developed prior to the year 2010 for meeting present single-purpose needs with development for multiple-purpose deferred to after the year 2010. The 39 small control projects in the recommended plan were selected by discrete screenings from 386 potential small dam sites inventoried in the basin. All selected 39 projects were found to be presently justified for development primarily for flood control with potential development for supplies of water and recreation as dictated by local needs. Thirty-six of these small projects would be constructed under continuing authorizations contained in Public Laws 566 and 685. Three of the small control projects exceed cost limitations imposed by Public Law 685 but are eligible for accomplishment under Public Law 566 subject to approval by the Senate Agriculture and Forestry Committee and the House Agriculture Committee.

2. Under the planning procedures followed in this survey for the formation of the plan of development, it has been demonstrated that the 58 selected water resource projects will satisfy both local and basin-wide current and future needs for the control of the water resources of the Delaware River Basin in the most efficient and economical manner. Those potential projects rejected in the process of program formation, through successive screening determinations, are not actual physical alternatives to any of the recommended projects in the plan of development. The application of the alternative evaluation standards, called for in Senate Resolution 148, to the rejected projects would provide no basis for findings substantially different from those contained in the report.

3. PROJECTS RECOMMENDED FOR AUTHORIZATION. Eight major control projects are recommended for authorization. These are Beltzville, Blue Marsh, Trexler, Prompton (modification), Tocks Island, Aquashicola, Maiden Creek and Bear Creek (modification). Additional information, called for in Senate Resolution 148, with respect to the eight projects recommended for authorization is presented in the following paragraphs.

4. BELTZVILLE PROJECT.

a. Description. The Beltzville Project site is located on Pohopoco Creek about 0.3 miles upstream from its confluence with Sawmill Run and 4 miles east of Lehighton, Pennsylvania. The proposed project would be a multiple-purpose development to provide supplies of water, flood control and recreation. Reservoir capacity to spillway crest level would be 68,200 acre-feet; 1,200 acre-feet inactive, 40,000 acre-feet for supplies of water and recreation, and 27,000 acre-feet for flood control. It would be formed by an earth and rock fill dam 4,500 feet long rising 160 feet above the creek bed, and have a spillway around the north end of the dam and gate-controlled outlet works discharging through a conduit on rock along the right abutment. The project would contribute to: (1) the satisfaction of the future water supply needs of downstream areas especially Palmerton, Bethlehem, and the Trenton-Philadelphia area; (2) the reduction in flood damages of especial importance in the highly industrialized Allentown, Bethlehem and Easton areas and in other smaller communities; and (3) the satisfaction of the desire for nonurban recreation facilities of the surrounding population. The Beltzville Project would be required by the year 1965.

b. Economic life. The economic life of the Beltzville Project as used in project analysis is 50 years.

c. Project costs. The estimated cost of construction is $13,800,000, excluding $1,190,000 for indirectly related recreation; the cost of operation and maintenance is $102,000 annually; and the cost of replacement is $5,600 annually. All costs are computed on the basis of 1959 price levels.

d. Benefit-cost ratios. Benefit-cost ratios were computed using total tangible benefits and total costs reflecting various interest rates applied to Federal and non-Federal interests for 50 years and 100 years. The benefit-cost ratio of the Beltzville Project for a 50-year economic life is 1.7 and for a 100-year economic life it is 2.0. Capital costs, operation and maintenance costs, replacement costs, and benefits for 50 years and 100 years are as follows:

	Amortization Period	
	50 Years	100 Years
CONSTRUCTION EXPENDITURES	$13,800,000	$13,800,000
ANNUAL CHARGES		
Interest and Amortization (including interest during construction)	558,000	454,000
Operation and Maintenance	102,000	102,000
Major Replacements	6,000	8,000
Economic Cost of Land	16,000	15,000
Total Annual Charges	682,000	578,000
ANNUAL BENEFITS		
Reduction of flood damages	286,000	293,000
Recreation, directly related	174,000	174,000
Supplies of water	669,000	675,000
Total Annual Benefits	1,130,000	1,140,000
BENEFIT-COST RATIO	1.7	2.0

Notes: Costs and benefits for indirectly related recreation are excluded. All amounts rounded; totals may not agree with sums of individual items due to rounding.
Interest rate of 2-5/8% used in determination of annual costs, where applicable, and discounting of future benefits.

e. *Intangible project effects*. Intangible effects of the Beltzville Project would include: a contribution to the prevention of loss of life, which amounted to 99 lives lost throughout the Delaware River Basin in the August 1955 flood; assurance values from assigning adequate flood control storage capacity at the Beltzville Project to control 71% of the standard project flood to non-damaging proportions so as to avoid a false sense of security from floods among the residents in the urban downstream reaches; and the value of the provision for sufficient site development at Beltzville Project to insure the realization of optimum recreation benefits. Adverse effects resulting from the Beltzville Project essentially would be a consequence of the damages expected to fish and wildlife resources in the project area. There is presented in appendix J to this report the acres of land and miles of stream that would be required to replace these resources in kind. No monetary equivalent for means of recovering such damages is presented.

f. *Physical feasibility and cost of providing for future needs*. The Beltzville Project has been formulated to contribute to the satisfaction of current and future needs for reduction of flood damages, recreation, and supplies of water over the economic life of the project. No provision has been made for later or phased construction at the Beltzville Project to satisfy known additional

future requirements in the area served by the project since it was found uneconomic to do so. System analyses for the four recommended major water control projects in the Lehigh River Basin; namely Beltzville, Trexler, Aquashicola, and Bear Creek, indicated that the satisfaction of additional and future requirements would be more economically achieved through the orderly development of the Trexler, Aquashicola and Bear Creek Projects, as recommended herein, than through the extension of the scale of development or phased construction of the Beltzville Project.

g. Allocation of costs. Allocation of costs were computed by (1) the separable costs-remaining benefits method, (2) the priority of use method, and (3) the incremental cost method on two time periods for amortization, 50 years and 100 years. The cost allocation data are shown in table AA-1. In the incremental cost method of allocation, supply of water was considered the basic function because the scheduled date for development of the project is based on the anticipated need for supplies of water.

h. Extent of interest in project. In order to take into account the desires and views of Federal Agencies, affected states and municipalities, during the survey and the preparation of the survey report, the District Engineer formally established the Delaware Basin Survey Coordinating Committee. This Committee was comprised of representatives of the States of Pennsylvania, New York, New Jersey, and Delaware; of the cities of Philadelphia and New York; and of the various Federal agencies concerned with water resources. Ten meetings of the Committee, which were open to the public, were held at about four-month intervals from April 1957 to March 1960 at various points throughout the Delaware River Basin and service area. Federal agencies, states and municipalities were informed at these various meetings as to the progress of the study and given the opportunity to review and comment on the features of the comprehensive plan. Also, a formal review procedure assured each member of the Coordinating Committee ample time to comment on the major features of the studies as they were reported on in the 24 appendices to the report. At the conclusion of the studies four public hearings were held in the basin to advise local interests of the findings of the study and afford them opportunities to express their views. It is believed that these interests are in general agreement with the plan presented. Under the review procedures prescribed for this survey report, local interests will have additional opportunity for comment on the features of the plan and cost sharing arrangements. Federal participation in this project has been estimated at \$6,280,000 for construction expenditures and \$74,000 annually for operation, maintenance and replacement costs during the period of deferred use of future water supplies and \$59,000 annually after use of the future water supplies is initiated.

i. Repayment schedules for reimbursable costs. The reimbursable cost for the Beltzville Project includes a construction

TABLE AA-1

ALLOCATIONS OF COST FOR BELTZVILLE PROJECT 1/

(All amounts rounded; totals may not agree with sums of individual items due to rounding)

	Amortization Period - 50 Years				Amortization Period - 100 Years			
	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total
SEPARABLE COSTS - REMAINING BENEFITS METHOD								
1. BENEFITS	$ 286,000	$ 174,000	$ 669,000	$1,130,000	$ 294,000	$ 174,000	$ 675,000	$ 1,140,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	206,000	94,000	328,000	628,000	168,000	83,000	264,000	516,000
b. Annual O & M and Replacement Costs	30,000	29,000	48,000	108,000	30,000	32,000	48,000	110,000
c. Specific Use Construction Expenditures	-	1,290,000	-	1,290,000	-	1,290,000	-	1,290,000
d. Joint-Use Facility Constr. Expenditures	4,720,000	268,000	7,540,000	12,500,000	4,760,000	264,000	7,500,000	12,500,000
e. Total Constr. Expenditures (First Cost)	4,720,000	1,550,000	7,540,000	13,800,000	4,760,000	1,550,000	7,500,000	13,800,000
PRIORITY OF USE METHOD 2/								
1. BENEFITS	286,000	174,000	669,000	1,130,000	294,000	174,000	675,000	1,140,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	286,000	114,000	228,000	628,000	258,000	105,000	153,000	516,000
b. Annual O & M and Replacement Costs	42,000	32,000	33,000	108,000	47,000	36,000	28,000	110,000
c. Specific Use Construction Expenditures	-	1,290,000	-	1,290,000	-	1,290,000	-	1,290,000
d. Joint-Use Facility Constr. Expenditures	6,560,000	743,000	5,220,000	12,500,000	7,300,000	889,000	4,330,000	12,500,000
e. Total Constr. Expenditures (First Cost)	6,560,000	2,030,000	5,220,000	13,800,000	7,300,000	2,180,000	4,330,000	13,800,000
INCREMENTAL COST METHOD 3/								
1. BENEFITS	286,000	174,000	669,000	1,130,000	294,000	174,000	675,000	1,140,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	159,000	82,000	387,000	628,000	129,000	73,000	314,000	516,000
b. Annual O & M and Replacement Costs	23,000	28,000	57,000	108,000	23,000	30,000	57,000	110,000
c. Specific Use Construction Expenditures	-	1,290,000	-	1,290,000	-	1,290,000	-	1,290,000
d. Joint-Use Facility Constr. Expenditures	3,670,000	-	8,860,000	12,500,000	3,670,000	-	8,860,000	12,500,000
e. Total Constr. Expenditures (First Cost)	3,670,000	1,290,000	8,860,000	13,800,000	3,670,000	1,290,000	8,860,000	13,800,000

1/ Fish and Wildlife benefits and costs discussed in Appendix J. No monetary equivalent given.

2/ Priority for assigning remaining costs: (1) reduction of flood damages; (2) directly related recreation; (3) supplies of water.

3/ Supplies of water considered the basic function to which all remaining costs are assigned.

NOTE: Interest rate of 2½% used in determination of annual costs and in discounting of future benefits.

expenditure of $7,540,000 for supplies of water. Alternative repayment schedules acceptable to the Federal government for the recovery of this cost are shown below:

Function	Construction Expenditures	Lump Sum	Annual Payment 1/	Deferred Lump Sum	Deferred Annual Payment 1/
Supplies of Water:	($7,540,000 rounded)				
Current Supply	3,393,000	$3,393,000	$128,000	N. A.	N. A.
Deferred Supply	4,144,000	4,144,000	156,000	$4,144,000 2/	$156,000

1/ Assumes Federal financing of such costs at 2-5/8%, and amortization period 50 years.
2/ Initiation of use of deferred supply within ten-year interest free period.
N.A. = not applicable.

In addition, non-Federal interests would be required to contribute $34,000 for the annual cost of operation, maintenance, and replacement during the period of deferred use of future water supplies and $48,000 annually after use of the future water supplies is initiated.

j. Effect of project on state and local governments. There are no major changes expected in the cost of state and local government services as a result of the Beltzville Project. Any increased costs of state and local services associated with the project have been taken into account in the estimate of annual operation and maintenance costs for the project. While there may be reductions in the revenues resulting from Federal acquisition of lands in the Beltzville Project area, it is expected that such reductions will be more than compensated for through increased activity, directly and indirectly associated with the multiple-purpose development features of the Beltzville Project.

5. BLUE MARSH PROJECT.

a. Description. The Blue Marsh Project site is located on Tulpehocken Creek about 1-1/2 miles upstream from its confluence with Plum Creek and about 6 miles northwest of Reading, Pennsylvania. The proposed project would be a multiple-purpose development to provide supplies of water, flood control and recreation. Reservoir capacity to spillway crest level would be 49,000 acre-feet; 1,500 acre-feet inactive, 14,500 acre-feet for supplies of water and recreation, and 33,000 acre-feet for flood control. It would be formed by an earth and rock fill dam 1,100 feet long and rising 90 feet above the creek bed, and have a spillway about 1,000 feet south of the dam and gate-controlled outlet works discharging through a conduit on rock along the right abutment. The project would contribute to: (1) the satisfaction of the future water supply needs of downstream areas especially the Reading-Pottstown and Philadelphia areas; (2) the reduction in flood damages of especial importance to such damage centers as Reading, Pottstown, Norristown, and Philadelphia; and (3) the satisfaction of the desire for nonurban recreation facilities of the surrounding population. The Blue Marsh Project would be required by the year 1969.

b. Economic life. The economic life of the Blue Marsh Project as used in project analysis is 50 years.

c. Project costs. The estimated cost of construction is $12,500,000, excluding $3,290,000 for indirectly related recreation; the cost of operation and maintenance is $106,000 annually; and the cost of major replacement is $5,000 annually. All costs are computed on the basis of 1959 price levels.

d. Benefit-cost ratios. Benefit-cost ratios were computed using total tangible benefits and total costs reflecting various interest rates applied to Federal and non-Federal interests for 50 years and 100 years. The benefit-cost ratio of the Blue Marsh Project for 50-year economic life is 1.6 and for 100-year economic life it is 2.0. Capital costs, operation and maintenance costs, replacement costs, and benefits for 50 years and 100 years are as follows:

	Amortization Period	
	50 Years	100 Years
CONSTRUCTION EXPENDITURES	$12,500,000	$12,500,000
ANNUAL CHARGES		
Interest and Amortization (including interest during construction)	483,000	386,000
Operation and Maintenance	106,000	106,000
Major Replacements	5,000	7,000
Economic Cost of Land	48,000	45,000
Total Annual Charges	642,000	544,000
ANNUAL BENEFITS		
Reduction of Flood Damages	301,000	316,000
Recreation, directly related	217,000	217,000
Supplies of water	530,000	539,000
Total Annual Benefits	1,050,000	1,070,000
BENEFIT-COST RATIO	1.6	2.0

Notes: Costs and benefits for indirectly related recreation are excluded.
All amounts rounded; totals may not agree with sums of individual items due to rounding.
Interest rate of 2-5/8% used in determination of annual costs, where applicable, and discounting of future benefits.

e. Intangible project effects. Intangible effects of the Blue Marsh Project would include: a contribution to the prevention of loss of life, which amounted to 99 lives lost throughout the Delaware River Basin in the August 1955 flood; assurance values from assigning adequate short-term storage capacity at the Blue Marsh Project to control 62% of the standard project flood to non-damaging proportions so as to avoid a false sense of security from floods among the residents in the urban downstream reaches; and the value of the provision for sufficient site development at the Blue Marsh Project to insure the realization of optimum recreation benefits. Adverse effects resulting from the Blue Marsh Project essentially would be a consequence of the damages expected to fish and wildlife resources in the project area. There is presented in appendix J to this report the acres of land and miles of stream that would be required to replace these resources in kind for a similar project, designated as Bernville, considered in the vicinity. No monetary equivalent for means of recovering such damages is presented.

f. Physical feasibility and cost of providing for future needs. The Blue Marsh Project has been formulated to contribute to the satisfaction of currect and future needs for reduction of flood damages, recreation, and supplies of water over the economic life of the project. No provision has been made for later or phased con-

struction at the Blue Marsh Projects to satisfy known additional future requirements in the area served by the project since it was found uneconomic to do so. Analysis of the water control requirements in the Schuylkill River Basin indicated that the satisfaction of additional or future requirements would be more economically achieved through the later development of the Maiden Creek Project, as recommended herein, than through the extension of the scale of development or phased construction of the Blue Marsh Project.

g. Allocations of costs. Allocation of costs were computed by (1) the separable costs-remaining benefits method; (2) the priority of use method; and (3) the incremental cost method on two time periods for amortization, 50 years and 100 years. The cost allocation data are shown in table AA-2. In the incremental cost method of allocation, supply of water was considered the basic function because the scheduled date for development of the project is based on the anticipated need for supplies of water.

h. Extent of interest in project. In order to take into account the desires and views of Federal agencies, affected states and municipalities, during the survey and the preparation of the survey report, the District Engineer formally established the Delaware Basin Survey Coordinating Committee. This Committee was comprised of representatives of the States of Pennsylvania, New York, New Jersey, and Delaware; of the cities of Philadelphia and New York; and of the various Federal agencies concerned with water resources. Ten meetings of the Committee, which were open to the public, were held at about four-month intervals from April 1957 to March 1960 at various points throughout the Delaware River Basin and service area. Federal agencies, states and municipalities were informed at these various meetings as to the progress of the study and given the opportunity to review and comment on the features of the comprehensive plan. Also, a formal review procedure assured each member of the Coordinating Committee ample time to comment on the major features of the studies as they were reported on in the 24 appendices to the report. At the conclusion of the studies four public hearings were held in the basin to advise local interests of the findings of the study and afford them opportunities to express their views. It is believed that these interests are in general agreement with the plan presented. Under the review procedures prescribed for this survey report, local interests will have additional opportunity for comment on the features of the plan and cost sharing arrangements. Federal participation in this project has been estimated at $7,100,000 for construction expenditures and $85,000 annually for operation, maintenance and replacement costs during the period of deferred use of future water supplies, and $72,000 annually after use of the future water supplies is initiated.

i. Repayment schedules for reimbursable costs. The reimbursable cost for the Blue Marsh Project would include a con-

TABLE AA-2

ALLOCATIONS OF COST FOR BLUE MARSH PROJECT[1/]

(All amounts rounded; totals may not agree with sums of individual items due to rounding)

	Amortization Period - 50 Years				Amortization Period - 100 Years			
	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total
SEPARABLE COSTS - REMAINING BENEFITS METHOD								
1. BENEFITS	$ 302,000	$ 217,000	$ 531,000	$ 1,050,000	$ 317,000	$ 217,000	$ 540,000	$ 1,070,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	240,000	120,000	252,000	611,000	213,000	104,000	190,000	508,000
b. Annual O&M and Replacement Costs	36,000	36,000	38,000	111,000	40,000	38,000	36,000	113,000
c. Specific Use Construction Expenditures	-	1,500,000	-	1,500,000	-	1,500,000	-	1,500,000
d. Joint-Use Facility Constr. Expenditures	5,140,000	457,000	5,410,000	11,000,000	5,580,000	429,000	5,000,000	11,000,000
e. Total Constr. Expenditures (First Cost)	5,140,000	1,950,000	5,410,000	12,500,000	5,580,000	1,930,000	5,000,000	12,500,000
PRIORITY OF USE METHOD 2/								
1. BENEFITS	302,000	217,000	531,000	1,050,000	317,000	217,000	540,000	1,070,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	302,000	142,000	167,000	611,000	317,000	130,000	61,000	508,000
b. Annual O&M and Replacement Costs	46,000	39,000	25,000	111,000	59,000	43,000	11,000	113,000
c. Specific Use Construction Expenditures	-	1,500,000	-	1,500,000	-	1,500,000	-	1,500,000
d. Joint-Use Facility Constr. Expenditures	6,480,000	939,000	3,590,000	11,000,000	8,310,000	1,120,000	1,590,000	11,000,000
e. Total Constr. Expenditures (First Cost)	6,480,000	2,430,000	3,590,000	12,500,000	8,310,000	2,610,000	1,590,000	12,500,000
INCREMENTAL COST METHOD 3/								
1. BENEFITS	302,000	217,000	531,000	1,050,000	317,000	217,000	540,000	1,070,000
2. ALLOCATION OF COST:								
a. Annual Economic Costs	180,000	99,000	332,000	611,000	148,000	88,000	272,000	508,000
b. Annual O&M and Replacement Costs	27,000	33,000	51,000	111,000	27,000	35,000	51,000	113,000
c. Specific Use Construction Expenditures	-	1,500,000	-	1,500,000	-	1,500,000	-	1,500,000
d. Joint-Use Facility Constr. Expenditures	3,870,000	-	7,140,000	11,000,000	3,870,000	-	7,140,000	11,000,000
e. Total Constr. Expenditures (First Cost)	3,870,000	1,500,000	7,140,000	12,500,000	3,870,000	1,500,000	7,140,000	12,500,000

1/ Fish and Wildlife benefits and costs discussed in Appendix J. No monetary equivalent given.

2/ Priority for assigning remaining costs: (1) reduction of flood damages; (2) directly related recreation; (3) supplies of water.

3/ Supplies of water considered the basic function to which all remaining costs are assigned.

NOTE: Interest rate of 2½% used in determination of annual costs and in discounting of future benefits.

struction cost of $5,410,000 for supplies of water. Alternative repayment schedules acceptable to the Federal government for recovery of this cost are shown below:

Function	Construction Expenditures	Lump Sum	Annual Payment 1/	Deferred Lump Sum	Deferred Annual Payment 1/
Supplies of Water:	($5,410,000 rounded)				
Current Supply	1,657,000	$1,657,000	$62,000	N. A.	N. A.
Deferred Supply	3,751,800	3,752,000	139,000	$3,752,000 2/	$139,000

1/ Assumes Federal financing of such costs at 2-5/8%, and amortization period 50 years.

2/ Initiation of use of deferred supply within ten-year interest free period.

N. A. - not applicable.

In addition, non-Federal interests would be required to contribute $26,000 annually for the cost of operation, maintenance and replacement during the period of deferred use of future water supplies and $38,000 annually after use of the future water supplies is initiated.

j. Effect of project on state and local governments. There are no major changes expected in the cost of state and local government services as a result of the Blue Marsh Project. Any increased costs of state and local services associated with the project have been taken into account in the estimate of annual operation and maintenance costs for the project. While there may be reductions in the tax revenues resulting from Federal acquisition of lands in the Blue Marsh Project area, it is expected that such reductions will be more than compensated for through increased activity, directly and indirectly associated with the multiple-purpose development features of the Blue Marsh Project.

6. TREXLER PROJECT.

a. Description. The Trexler Project site is located on Jordan Creek about 1/2 mile downstream from its confluence with Mill Creek and 8 miles northwest of Allentown, Pennsylvania. The proposed project would be a multiple-purpose development to provide supplies of water, flood control and recreation. Reservoir capacity to spillway crest level would be 39,000 acre-feet; 800 acre-feet inactive, 24,200 acre-feet for supplies of water and recreation, and 14,000 acre-feet for flood control. It would be formed by a concrete gravity type dam 800 feet long and rising 120 feet above the creek bed, and have a spillway in the stream channel and gate-controlled outlet works discharging through sluices in the spillway section. The project would contribute to: (1) the satisfaction of the future water supply needs of downstream areas especially the Allentown-Bethlehem and Trenton-Philadelphia areas; (2) the reduction in flood damages of especial importance in the highly industrialized Allentown, Bethlehem and Easton areas; and (3) the satisfaction of the desire for nonurban recreation facilities of the surrounding population. The Trexler Project would be required by the year 1972.

b. Economic life. The economic life of the Trexler Project as used in project analysis is 50 years.

c. Project costs. The estimated cost of construction is $10,100,000, excluding $1,140,000 for indirectly related recreation; the cost of operation and maintenance is $101,000 annually; and the cost of major replacement is $3,000 annually. All costs are computed on the basis of 1959 price levels.

d. Benefit-cost ratios. Benefit-cost ratios were computed using total tangible benefits and total costs reflecting various interest rates applied to Federal and non-Federal interests for 50 years and 100 years. The benefit-cost ratio of the Trexler Project for 50-year economic life is 1.6 and for 100-year economic life it is 1.8. Capital costs, operation and maintenance costs, replacement costs, and benefits for 50 years and 100 years are as follows:

	Amortization Period	
	50 Years	100 Years
CONSTRUCTION EXPENDITURES	$10,100,000	$10,100,000
ANNUAL CHARGES		
Interest and Amortization (including interest during construction)	404,000	330,000
Operation and Maintenance	101,000	101,000
Major Replacements	3,000	4,000
Economic Cost of Land	44,000	40,000
Total Annual Charges	552,000	475,000
ANNUAL BENEFITS		
Reduction of Flood Damages	114,000	116,000
Recreation, directly related	281,000	281,000
Supplies of Water	463,000	466,000
Total Annual Benefits	858,000	864,000
BENEFIT-COST RATIO	1.6	1.8

Notes: Costs and benefits for indirectly related recreation are excluded.
All amounts rounded; totals may not agree with sums of individual items due to rounding.
Interest rate of 2-5/8% used in determination of annual costs, where applicable, and in discounting of future benefits.

e. Intangible project effects. Intangible project effects of the Trexler Project would include: a contribution to the prevention of loss of life, which amounted to 99 lives lost throughout the Delaware River basin in the August 1955 flood; assurance values from assigning adequate flood control storage capacity at the Trexler Project to control 71% of the standard project flood to non-damaging proportions so as to avoid a false sense of security from floods among the residents in the urban downstream reaches; and the value of the provision for sufficient site development at the Trexler Project to insure the realization of optimum recreation benefits. Adverse effects resulting from the Trexler Project would essentially be a consequence of the damages expected to wildlife resources in the project area. There is presented in appendix J to this report the acres of land that would be required to replace these resources in kind. No monetary equivalent for means of recovering such damages is presented.

f. Physical feasibility and cost of providing for future needs. The Trexler Project has been formulated to contribute to the satisfaction of current and future needs for reduction of flood damages, recreation, and supplies of water over the economic life of the project. No provision has been made for later or phased construction at the Trexler Project to satisfy known additional future requirements in the area served by the

project since it was found uneconomic to do so. System analyses for the four recommended major water control projects in the Lehigh River Basin, namely, Beltzville, Trexler, Aquashicola and Bear Creek, indicated that the satisfaction of additional and future requirements would be more economically achieved through the orderly development of the Beltzville, Aquashicola and Bear Creek Projects, as recommended herein, than through the extension of the scale of development or phased construction of the Trexler project.

g. Allocation of costs. Allocation of costs were computed by (1) the separable costs-remaining benefits method; (2) the priority of use method; and (3) the incremental cost method on two time periods for amortization, 50 years and 100 years. The cost allocation data are shown in table AA-3. In the incremental cost method of allocation, supply of water was considered the basic function because the scheduled date for development of the project is based on the anticipated need for supplies of water.

h. Extent of interest in project. In order to take into account the desires and views of Federal agencies, affected states and municipalities, during the survey and the preparation of the survey report, the District Engineer formally established the Delaware Basin Survey Coordinating Committee. This Committee was comprised of representatives of the States of Pennsylvania, New York, New Jersey, and Delaware; of the cities of Philadelphia and New York; and of the various Federal agencies concerned with water resources. Ten meetings of the Committee, which were open to the public, were held at about four month intervals from April 1957 to March 1960, at various points throughout the Delaware River Basin and service area. Federal agencies, states and municipalities were informed at these various meetings as to the progress of the study and given the opportunity to review and comment on the features of the comprehensive plan. Also, a formal review procedure assured each member of the Coordinating Committee ample time to comment on the major features of the studies as they were reported on in the 24 appendices to the report. At the conclusion of the studies four public hearings were held in the basin to advise local interests of the findings of the study and afford them opportunities to express their views. It is believed that these interests are in general agreement with the plan presented. Under the review procedures prescribed for this survey report, local interests will have additional opportunity for comment on the features of the plan and cost sharing arrangements. Federal participation in this project has been estimated at $4,300,000 for construction expenditures and $69,000 annually for operation, maintenance and replacement costs during the period of deferred use of future water supplies, and $57,000 annually after use of future water supplies is initiated.

i. Repayment schedules for reimbursable costs. The reimbursable cost for the Trexler Project would include a construction ex-

TABLE AA-3

ALLOCATIONS OF COST FOR TREXLER PROJECT 1/

(All amounts rounded; totals may not agree with sums of individual items due to rounding)

	Amortization Period - 50 Years				Amortization Period - 100 Years			
	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total
SEPARABLE COSTS - REMAINING BENEFITS METHOD								
1. BENEFITS	$ 114,000	$ 281,000	$ 464,000	$ 859,000	$ 117,000	$ 281,000	$ 467,000	$ 865,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	97,000	151,000	263,000	512,000	87,000	131,000	210,000	427,000
b. Annual O&M and Replacement Costs	18,000	40,000	47,000	104,000	19,000	41,000	46,000	106,000
c. Specific Use Construction Expenditures	-	1,500,000	-	1,500,000	-	1,500,000	-	1,500,000
d. Joint-Use Facility Constr. Expenditures	2,150,000	653,000	5,770,000	8,570,000	2,330,000	628,000	5,610,000	8,570,000
e. Total Constr. Expenditures (First Cost)	2,150,000	2,150,000	5,770,000	10,100,000	2,330,000	2,130,000	5,610,000	10,000,000
PRIORITY OF USE METHOD 2/								
1. BENEFITS	114,000	281,000	464,000	859,000	117,000	281,000	467,000	865,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	114,000	185,000	213,000	512,000	117,000	169,000	142,000	427,000
b. Annual O&M and Replacement Costs	20,000	46,000	38,000	104,000	26,000	49,000	31,000	106,000
c. Specific Use Construction Expenditures	-	1,500,000	-	1,500,000	-	1,500,000	-	1,500,000
d. Joint-Use Facility Constr. Expenditures	2,490,000	1,410,000	4,670,000	8,570,000	3,120,000	1,650,000	3,790,000	8,570,000
e. Total Constr. Expenditures (First Cost)	2,490,000	2,910,000	4,670,000	10,100,000	3,120,000	3,150,000	3,790,000	10,100,000
INCREMENTAL COST METHOD 3/								
1. BENEFITS	114,000	281,000	464,000	859,000	117,000	281,000	467,000	865,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	83,000	120,000	309,000	512,000	68,000	107,000	253,000	427,000
b. Annual O&M and Replacement Costs	15,000	34,000	55,000	104,000	15,000	36,000	55,000	106,000
c. Specific Use Construction Expenditures	-	1,500,000	-	1,500,000	-	1,500,000	-	1,500,000
d. Joint-Use Facility Constr. Expenditures	1,830,000	-	6,740,000	8,570,000	1,830,000	-	6,740,000	8,570,000
e. Total Constr. Expenditures (First Cost)	1,830,000	1,500,000	6,740,000	10,100,000	1,830,000	1,500,000	6,740,000	10,100,000

1/ Fish and wildlife benefits and costs discussed in Appendix J. No monetary equivalent given.

2/ Priority for assigning remaining costs: (1) reduction of flood damages; (2) directly related recreation; (3) supplies of water.

3/ Supplies of water considered the basic function to which all remaining costs are assigned.

NOTE: Interest rate of 2½% used in determination of annual costs and in discounting of future benefits.

penditure of $5,770,000 for supplies of water. Alternative repayment schedules acceptable to the Federal government for the recovery of this cost are shown below:

Function	Construction Expenditures	Lump Sum	Annual Payment 1/	Deferred Lump Sum	Deferred Annual Payment 1/
Supplies of Water	($5,770,000 rounded)				
Current Supply	2,747,000	$2,747,000	$102,000	N. A.	N. A.
Deferred Supply	3,019,000	3,019,000	112,000	$3,019,000 2/	$112,000

1/ Assumes Federal financing of such costs at 2-5/8%, amortization period 50 years.
2/ Initiation of use of deferred supply within ten-year interest free period.
N. A. = not applicable.

In addition, non-Federal interests would be required to contribute $35,000 annually for the cost of operation, maintenance and replacement during the period of deferred use of future water supplies and $47,000 annually after use of the future water supplies is initiated

j. Effect of project on state and local governments. There are no major changes expected in the cost of state and local government services as a result of the Trexler Project. Any increased costs of state and local services associated with the project have been taken into account in the estimate of annual operation and maintenance costs for the project. While there may be reductions in the tax revenues resulting from Federal acquisition of lands in the Trexler Project area, it is expected that such reduction would be more than compensated for through increased activity, directly and indirectly associated with the multiple-purpose development features of the Trexler Project.

7. PROMPTON PROJECT.

a. Description. The Prompton Project is a modification of the single-purpose flood control project, now under construction, which is located on Lackawaxen River about 1/2 mile upstream from its confluence with Waymart Branch and about 4 miles west of Honesdale, Pennsylvania. The proposed project would be a multiple-purpose development to provide for supplies of water and recreation in addition to the present flood control purpose. Reservoir capacity to spillway crest level would be 51,700 acre-feet; 3,400 acre-feet inactive, 28,000 acre-feet for supplies of water and recreation, and 20,300 acre-feet for flood control. The proposed modification would require construction of a control tower with gates and service bridge, placing an impervious blanket on the valley walls and floor upstream from the dam, widening of the spillway, and clearing land and relocating roads in the reservoir. The dam presently under construction, which would not be modified, will be 1,300 feet long and rise 140 feet above the river bed. The existing spillway which is cut into the rock of the right abutment, will be modified and the present uncontrolled outlet works, discharging into a concrete conduit along the right bank, will be provided with gates and a control tower. The modified project would contribute to: (1) the future water supply needs of the Trenton-Philadelphia area; (2) the reduction in flood damages in the downstream areas of especial importance to Honesdale, Hawley, and the lower reaches of Lackawaxen River; and (3) the satisfaction of the desire for nonurban recreation facilities of the surrounding population. The Prompton Project would be required by the year 1974.

b. Economic life. The economic life of the Prompton Project from the time modifications are completed and including features of the existing project as used in project analysis is 50 years.

c. Project costs. The estimated cost of construction, excluding $387,000 for indirectly related recreation, is $8,050,000 which is made up of $3,700,000 estimated as the cost of the flood control project now under construction and $4,350,000 estimated as the cost for the modifications for multiple-purpose development. The total new construction expenditures required, including $620,000 for rehabilitation of the existing project would be $4,970,000. The estimated annual operation and maintenance cost is $82,000, and the major replacement cost is estimated at $2,000 annually. All costs are computed on the basis of 1959 price levels.

d. Benefit-cost ratios. Benefit-cost ratios were computed using total tangible benefits and total costs reflecting various interest rates applied to Federal and non-Federal interests for 50 years and 100 years. The economic justification for the Prompton Project was based on the premise that the modification constituted a second stage of development and rehabilitation to provide feasible comprehensive development with a 50-year life expectancy. The benefit-cost ratio of

the Prompton Project for a 50-year economic life is 1.4 and for a 100-year economic life it is 1.6. Capital costs, operation and maintenance costs, replacement costs, and benefits for 50 years and 100 years are as follows:

	Amortization Period	
	50 Years	100 Years
NEW CONSTRUCTION EXPENDITURES	$ 4,970,000	$ 4,970,000
ANNUAL CHARGES		
Interest and Amortization (including interest during construction)	239,000	197,000
Operation & Maintenance	82,000	82,000
Major Replacements	2,000	2,000
Economic Cost of Land	26,000	24,000
Total Annual Charges	348,000	305,000
ANNUAL BENEFITS		
Reduction of Flood Damages	49,000	49,000
Recreation	130,000	130,000
Supplies of Water	307,000	307,000
Total Annual Benefits	486,000	486,000
BENEFIT-COST RATIO	1.4	1.6

Notes: Costs and benefits for indirectly related recreation are excluded.
All amounts rounded; totals may not agree with sums of individual items due to rounding.
Interest rate of 2-5/8% used in determination of annual costs, where applicable, and discounting of future benefits.

e. Intangible project effects. Intangible project effects of the Prompton Project would include: a contribution to the prevention of loss of life, which amounted to 99 lives lost throughout the Delaware River Basin in the August 1955 flood; assurance values from assigning adequate flood control storage capacity at the Prompton Project to control 69% of the standard project flood to non-damaging proportions so as to avoid a false sense of security from floods among the residents in the urban downstream reaches; and the value of the provision for sufficient site development at the Prompton Project to insure the realization of optimum recreation benefits. Adverse effects resulting from the Prompton Project essentially would be a consequence of the damages expected to fish and wildlife resources in the project area. There is presented in appendix J to this report a discussion of how such damages attributable to other projects in the plan of development might be mitigated. No monetary equivalent for means of recovering such damages is presented.

f. Physical feasibility and cost of providing for future needs. The Prompton Project has been formulated to contribute to the satisfaction of current and future needs for reduction of flood damages, recreation, and supplies of water over the economic life of the project. No provision has been made for further modification at the Prompton Project to satisfy known additional future requirements in the area served by this project since it was found uneconomic to do so. Given the magnitude of future water control requirements, it was determined that the satisfaction of such needs would be more economically achieved through the orderly development of the remaining major control projects scheduled for development after completion of modifications at Prompton, as recommended herein, than through additional modifications of the scale of development of the Prompton Project.

g. Allocation of costs. Allocation of costs were computed by (1) the separable costs-remaining benefits method, (2) the priority of use method, and (3) the incremental cost method on two time periods for amortization, 50 years and 100 years. The cost allocation data are shown in table AA-4. In the incremental cost method of allocation, supply of water was considered the basic function because the scheduled date for modification of the existing project is based on the anticipated need for supplies of water.

h. Extent of interest in project. In order to take into account the desires and views of Federal agencies, affected states and municipalities, during the survey and the preparation of the survey report, the District Engineer formally established the Delaware Basin Survey Coordinating Committee. This Committee was comprised of representatives of the States of Pennsylvania, New York, New Jersey, and Delaware; of the cities of Philadelphia and New York; and of the various Federal agencies concerned with water resources. Ten meetings of the Committee, which were open to the public, were held at about four-month intervals from April 1957 to March 1960 at various points throughout the Delaware River Basin and service area. Federal agencies, states and municipalities were informed at these various meetings as to the progress of the study and given the opportunity to review and comment on the features of the comprehensive plan. Also, a formal review procedure assured each member of the Coordinating Committee ample time to comment on the major features of the studies as they were reported on in the 24 appendices to the report. At the conclusion of the studies four public hearings were held in the basin to advise local interests of the findings of the study and afford them opportunities to express their views. It is believed that these interests are in general agreement with the plan presented. Under the review procedures prescribed for this survey report local interests will have additional opportunity for comment on the features of the plan and cost sharing arrangements. Federal participation in this project has been estimated at \$ 463,000 for new construction expenditures and \$45,000

TABLE AA-4

ALLOCATIONS OF COST FOR PROMPTON PROJECT 1/

(All amounts rounded; totals may not agree with sums of individual items due to rounding)

	Amortization Period - 50 Years				Amortization Period - 100 Years			
	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total
SEPARABLE COSTS - REMAINING BENEFITS METHOD								
1. BENEFITS	$ 295,000	$ 130,000	$ 307,000	$ 732,000	$ 295,000	$ 130,000	$ 307,000	$ 732,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	122,000	51,000	228,000	400,000	95,000	44,000	194,000	333,000
b. Annual O&M and Replacement Costs	10,000	19,000	54,000	84,000	10,000	20,000	55,000	84,000
c. Specific Use Construction Expenditures	-	427,000	-	427,000	-	427,000	-	427,000
d. Joint-Use Facility Constr. Expenditures	2,860,000	254,000	4,500,000	7,620,000 2/	2,800,000	234,000	4,590,000	7,620,000 2/
e. Total Constr. Expenditures (First Cost)	2,860,000	681,000	4,500,000	8,050,000 2/	2,800,000	661,000	4,590,000	8,050,000 2/
PRIORITY OF USE METHOD 3/								
1. BENEFITS	295,000	130,000	307,000	732,000	295,000	130,000	307,000	732,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	168,000	85,000	147,000	400,000	136,000	78,000	119,000	333,000
b. Annual O&M and Replacement Costs	30,000	27,000	26,000	84,000	30,000	29,000	26,000	84,000
c. Specific Use Construction Expenditures	-	427,000	-	427,000	-	427,000	-	427,000
d. Joint-Use Facility Constr. Expenditures	3,520,000	1,020,000	3,080,000	7,620,000 2/	3,460,000	1,130,000	3,020,000	7,620,000 2/
e. Total Constr. Expenditures (First Cost)	3,520,000	1,450,000	3,080,000	8,050,000 2/	3,460,000	1,560,000	3,020,000	8,050,000 2/
INCREMENTAL COST METHOD 4/								
1. BENEFITS	295,000	130,000	307,000	732,000	295,000	130,000	307,000	732,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	102,000	36,000	261,000	400,000	82,000	34,000	218,000	333,000
b. Annual O&M and Replacement Costs	8,000	18,000	57,000	84,000	8,000	19,000	57,000	84,000
c. Specific Use Construction Expenditures	-	427,000	-	427,000	-	427,000	-	427,000
d. Joint-Use Facility Constr. Expenditures	2,520,000	-	5,100,000	7,620,000 2/	2,520,000	-	5,100,000	7,620,000 2/
e. Total Constr. Expenditures (First Cost)	2,520,000	427,000	5,100,000	8,050,000 2/	2,520,000	427,000	5,100,000	8,050,000 2/

1/ Fish and Wildlife benefits and costs discussed in Appendix J. No monetary equivalent given.
2/ Includes existing flood control project cost of $3,700,000.
3/ Priority for assigning remaining costs: (1) reduction of flood damages; (2) directly related recreation; (3) supplies of water.
4/ Supplies of water considered the basic function to which all remaining costs are assigned.
NOTE: Interest rate of 2½% used in determination of annual costs and discounting of future benefits.

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annually for operation, maintenance and replacement costs during the period of deferred use of future water supplies and a total of $29,000 annually after use of the future water supplies is initiated.

i. Repayment schedules for reimbursable costs. The reimbursable cost for the Prompton Project would include a construction cost of $4,500,000 for supplies of water. Alternate repayment schedules acceptable to the Federal government for the recovery of this cost are shown below:

Function	Construction Expenditure	Lump Sum	Annual Payment 1/	Deferred Lump Sum	Deferred Annual Payment 1/
Supplies of Water	$4,500,000 (rounded)				
Current Supply	2,089,000	$2,089,000	$78,000	N. A.	N. A.
Deferred Supply	2,414,000	2,414,000	90,000	$2,414,000 2/	$90,000

1/ Assumes Federal financing of such costs at 2-5/8%, amortization period 50 years.

2/ Initiation of use of deferred supply within ten-year interest free period.

N. A. - not applicable.

In addition, non-Federal interests would be required to contribute $38,000 annually for the cost of operation, maintenance and replacement during the period of deferred use of future water supplies and $54,000 annually after use of the future water supply is initiated.

j. Effect of project on state and local governments. There are no major changes expected in the cost of state and local government services as a result of the Prompton Project. Any increased costs of state and local services associated with the project have been taken into account in the estimate of annual operation and maintenance costs for the project. While there may be reductions in the revenues resulting from Federal acquisition of lands in the Prompton Project area, it is expected that such reductions would be more than compensated for through increased activity, directly and indirectly associated with the multiple-purpose development features of the Prompton Project.

8. TOCKS ISLAND PROJECT.

a. Description. The Tocks Island Project site is located on Delaware River about 5 miles upstream from Delaware Water Gap and about 7 miles northeast of Stroudsburg, Pennsylvania. The proposed project would be a multiple-purpose development to provide supplies of water, flood control, production of hydroelectric power, and recreation. Reservoir capacity to level of top of spillway gates would be 765,000 acre-feet; 80,000 acre-feet inactive, 410,000 acre-feet for supplies of water, power and recreation, and 275,000 acre-feet for flood control. The dam would be of earth and rock fill 3,200 feet long and rising 160 feet above the river bed. A spillway would be cut in the rock of the left abutment, and it would be lined with concrete and provided with crest gates. A gate-controlled outlet works, discharging through concrete conduits on rock along the left bank, would regulate releases either through the turbines in the powerhouse at the downstream end of the conduits or through by-pass channels in the powerhouse substructure. A pumped-storage powerhouse would be located underground, upstream from the dam, on the left side. The project would contribute to: (1) the future water supply needs of the Trenton-Philadelphia area; (2) the reduction in flood damages in the downstream areas of especial importance to the Delaware Water Gap-to-Trenton section; (3) the satisfaction of the future demand for electric energy in the area; and (4) the satisfaction of the desire for nonurban recreation facilities of the regional population. The Tock Island Project would be required in the year 1975.

b. Economic life. The economic life of the Tocks Island Project as used in project analysis is 50 years.

c. Project costs. The estimated cost of construction, annual cost of operation and maintenance, and annual cost of major replacements are as follows:

	1/	2/	3/
Construction expenditures	$146,000,000	$122,000,000	$177,000,000
Operation and maintenance	4,460,000	1,760,000	5,310,000
Major replacements	204,000	207,000	320,000

1/ Flood control, water supply, directly related recreation, and conventional and pumped-storage hydropower.

2/ Flood control, water supply, directly and indirectly related recreation and conventional hydropower.

3/ Flood control, water supply, directly and indirectly related recreation, and conventional and pumped-storage hydropower.

All amounts are rounded and are computed on the basis of 1959 price levels.

d. Benefit-cost ratios. Benefit-cost ratios were computed using total tangible benefits and total costs reflecting various interest rates applied to Federal and non-Federal interests for 50 years and 100 years. The benefit-cost ratio of the Tocks Island Project for a 50-year economic life is 2.2 without the pumped-storage hydro-power feature. This ratio was computed with the total recreation benefits and costs (directly and indirectly related) included. The comparable figure for 100-year economic life is 2.6. Capital costs, operation and maintenance, replacement costs, and benefits for 50 years and 100 years are as follows:

	50 years	100 years
CONSTRUCTION EXPENDITURES	1/ $122,000,000	1/ $122,000,000
ANNUAL CHARGES:		
Interest and Amortization (including interest during construction)	4,700,000	3,700,000
Operation and Maintenance	1,760,000	1,760,000
Replacements	207,000	318,000
Economic Cost of Land	697,000	641,000
Taxes	335,000	335,000
Total Annual Charges	7,700,000	6,750,000
ANNUAL BENEFITS:		
Reduction of Flood Damages	1,460,000	1,500,000
Recreation (directly & indirectly related)	10,000,000	10,000,000
Supplies of Water	3,780,000	4,090,000
Power	1,820,000	1,820,000
Total Annual Benefits	17,100,000	17,400,000
BENEFIT-COST RATIO	2.2	2.6

1/ Excluding pumped-storage hydropower.

Notes: All amounts rounded; totals may not agree with sums of individual items due to rounding.
Interest rate of 2-5/8% used in determination of annual costs, where applicable, and discounting of future benefits.

e. Intangible project effects. Intangible project effects of the Tocks Island Project would include: a contribution to the prevention of loss of life, which amounted to 99 lives lost throughout the Delaware River Basin in the August 1955 flood; assurance values from assigning adequate flood control storage capacity at the Tocks Island Project to control 54% of the standard project flood to non-damaging proportions so as to avoid a false sense of security from floods among the residents in the urban downstream reaches; and the value of the provision for sufficient site development at Tocks Island Project to insure the realization of optimum recreation benefits. Adverse effects resulting from the Tocks Island Project essentially would be a consequence of the damages expected to fish and wildlife resources in the project area. There is presented in appendix J to this report the acres of land and miles of stream that would be required to replace these resources in kind. No monetary equivalent for means of recovering such damages is presented. Some project facilities for fisheries have been included and are considered in the overall joint-use construction expenditures for this project.

f. Physical feasibility and cost of providing for future needs. The Tocks Island Project has been formulated to contribute to the satisfaction of current and future needs for reduction of flood damages, recreation, supplies of water, and hydroelectric power over the economic life of the project. No provision has been made for later or phased construction at the Tocks Island Project to satisfy known additional future water control requirements since it would be uneconomic to do so. Site limitation at Tocks Island above elevation 428 involving costs for protecting the Port Jervis area precludes the extension of the scale of development at Tocks Island as recommended herein. Further consideration given to the role of the other major control projects, to be developed in a logical time sequence, indicated that the satisfaction of additional and future requirements could be more economically achieved through use and development of these projects than through further site development at Tocks Island.

g. Allocation of costs. Allocation of costs were computed by (1) the separable costs-remaining benefits method, (2) the priority of use method, and (3) the incremental cost method on two time periods for amortization, 50 years and 100 years. The cost allocation data are shown in table AA-5. In the incremental cost method of allocation, supply of water was considered the basic function because the scheduled date for development of the project is based on the anticipated need for supplies of water.

h. Extent of interest in project. In order to take into account the desires and views of Federal agencies, affected states and municipalities, during the survey and the preparation of the survey report, the District Engineer formally established the Delaware Basin Survey Coordinating Committee. This Committee was comprised of representatives of the States of Pennsylvania, New York, New Jersey, and Delaware; of the cities of Philadelphia and New York; and of the various Federal agencies concerned with water

TABLE AA-5

ALLOCATIONS OF COST FOR TOCKS ISLAND PROJECT 1/

(All amounts rounded; totals may not agree with sums of individual items due to rounding)

Amortization Period - 50 Years

	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Power: Conventional	Power: Pumped Storage	Total
SEPARABLE COSTS - REMAINING BENEFITS METHOD						
1. BENEFITS	$ 1,460,000	$ 3,660,000	$ 3,810,000	$ 1,820,000	$ 11,000,000	$ 21,800,000
2. ALLOCATION OF COSTS:						
a. Annual Economic Costs	552,000	1,650,000	1,080,000	1,370,000	9,010,000	13,700,000
b. Annual O&M and Replacement Costs	52,000	577,000	86,000	254,000	3,690,000	4,660,000
c. Specific Use Construction Expenditures	-	18,200,000	-	12,300,000	53,800,000	84,400,000
d. Joint-Use Facility Constr. Expenditures	12,100,000	6,620,000	24,000,000	8,100,000	10,500,000	61,400,000
e. Total Constr. Expenditures (First Cost)	12,100,000	24,900,000	24,000,000	20,400,000	64,300,000	146,000,000
PRIORITY OF USE METHOD 2/						
1. BENEFITS	1,460,000	3,660,000	3,810,000	1,820,000	11,000,000	21,800,000
2. ALLOCATION OF COSTS:						
a. Annual Economic Costs	1,460,000	2,400,000	200,000	1,040,000	8,570,000	13,700,000
b. Annual O&M and Replacement Costs	104,000	633,000	14,000	243,000	3,670,000	4,660,000
c. Specific Use Construction Expenditures	-	18,200,000	-	12,300,000	53,800,000	84,400,000
d. Joint-Use Facility Constr. Expenditures	33,200,000	23,600,000	4,570,000	-	-	61,400,000
e. Total Constr. Expenditures (First Cost)	33,200,000	41,800,000	4,570,000	12,300,000	53,800,000	146,000,000
INCREMENTAL COST METHOD 3/						
1. BENEFITS	1,460,000	3,660,000	3,810,000	1,820,000	11,000,000	21,800,000
2. ALLOCATION OF COSTS:						
a. Annual Economic Costs	207,000	1,370,000	2,280,000	1,200,000	8,610,000	13,700,000
b. Annual O&M and Replacement Costs	30,000	558,000	164,000	243,000	3,670,000	4,660,000
c. Specific Use Construction Expenditures	-	18,200,000	-	12,300,000	53,800,000	84,400,000
d. Joint-Use Facility Constr. Expenditures	4,130,000	-	52,100,000	4,040,000	1,130,000	61,400,000
e. Total Constr. Expenditures (First Cost)	4,130,000	18,200,000	52,100,000	16,400,000	55,000,000	146,000,000

Amortization Period - 100 Years

	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Power: Conventional	Power: Pumped Storage	Total
SEPARABLE COSTS - REMAINING BENEFITS METHOD						
1. BENEFITS	$ 1,500,000	$ 3,660,000	$ 4,120,000	$ 1,820,000	$11,000,000	$ 22,200,000
2. ALLOCATION OF COSTS:						
a. Annual Economic Costs	459,000	1,440,000	799,000	1,260,000	8,680,000	12,600,000
b. Annual O&M and Replacement Costs	53,000	602,000	80,000	291,000	3,850,000	4,870,000
c. Specific Use Construction Expenditures	-	18,200,000	-	12,300,000	53,800,000	84,400,000
d. Joint-Use Facility Constr. Expenditures	12,600,000	6,100,000	22,000,000	[illegible],640,000	12,100,000	61,400,000
e. Total Constr. Expenditures (First Cost)	12,600,000	24,300,000	22,000,000	21,000,000	65,900,000	146,000,000
PRIORITY OF USE METHOD 2/						
1. BENEFITS	1,500,000	3,660,000	4,120,000	1,820,000	11,000,000	22,200,000
2. ALLOCATION OF COSTS:						
a. Annual Economic Costs	1,500,000	1,890,000	-	975,000	8,270,000	12,600,000
b. Annual O&M and Replacement Costs	134,000	644,000	-	279,000	3,820,000	4,870,000
c. Specific Use Construction Expenditures	-	18,200,000	-	12,300,000	53,800,000	84,400,000
d. Joint-Use Facility Constr. Expenditures	42,700,000	18,600,000	-	-	-	61,400,000
e. Total Constr. Expenditures (First Cost)	42,700,000	36,900,000	-	12,300,000	53,800,000	146,000,000
INCREMENTAL COST METHOD 3/						
1. BENEFITS	1,500,000	3,660,000	4,120,000	1,820,000	11,000,000	22,200,000
2. ALLOCATION OF COSTS:						
a. Annual Economic Costs	170,000	1,230,000	1,830,000	1,100,000	8,300,000	12,600,000
b. Annual O&M and Replacement Costs	30,000	585,000	164,000	279,000	3,820,000	4,870,000
c. Specific Use Construction Expenditures	-	18,200,000	-	12,300,000	53,800,000	84,400,000
d. Joint-Use Facility Constr. Expenditures	4,130,000	-	52,100,000	4,040,000	1,130,000	61,400,000
e. Total Constr. Expenditures (First Cost)	4,130,000	18,200,000	52,100,000	16,400,000	55,000,000	146,000,000

1/ Fish and Wildlife benefits and costs discussed in Appendix J. No monetary equivalent given.
2/ Priority for assigning remaining costs: (1) reduction of flood damages; (2) directly related recreation; (3) supplies of water; (4) conventional power; (5) pumped-storage power.
3/ Supplies of water considered the basic function to which all remaining costs are assigned.
NOTE: Interest rate of 2½% used in determination of annual costs and discounting of future benefits.

resources. Ten meetings of the Committee, which were open to the public, were held at about four-month intervals from April 1957 to March 1960, at various points throughout the Delaware River Basin and service area. Federal agencies, states and municipalities were informed at these various meetings as to the progress of the study and given the opportunity to review and comment on the features of the comprehensive plan. Also, a formal review procedure assured each member of the Coordinating Committee ample time to comment on the major features of the studies as they were reported on in the 24 appendices to the report. At the conclusion of the studies four public hearings were held in the basin to advise local interests of the findings of the study and afford them opportunities to express their views. It is believed that these interests are in general agreement with the plan presented. Under the review procedures prescribed for this survey report, local interest will have additional opportunity for comment on the features of the plan and cost sharing arrangements. Federal participation in the Tocks Island Project would be as follows:

CONSTRUCTION EXPENDITURES	1/ $93,900,000
Annual Operation, Maintenance and Replacements 2/	1,870,000 (1,950,000)

1/ Excluding pumped-storage hydropower.
2/ Amounts in parentheses are O M & R during period of deferred use of water supplies.

i. Repayment schedules for reimbursable costs. Costs apportioned to non-Federal interests are as follows:

CONSTRUCTION EXPENDITURES	1/ $28,500,000
Annual Operation, Maintenance and Replacements 2/	98,000 (20,000)

1/ Excluding pumped-storage hydropower.
2/ Amounts in parentheses are O M & R during period of deferred use of water supplies.

Alternative repayment schedules acceptable to the Federal government for recovery of these costs are shown below:

Function	Construction Expenditure	Lump Sum	Annual 1/ Payment	Deferred Lump Sum	Deferred 1/ Annual Payment
Supplies of Water 2/	($28,500,000 rounded)				
Current Supply	1,248,000	$1,248,000	$48,000	N.A.	N.A.
Deferred Supply	27,241,000	27,241,000	1,050,000	$27,241,000 3/	$1,050,000

1/ Assumes Federal financing of such costs at 2-5/8%, and amortization period of 50 years.
2/ Pumped-storage hydropower excluded.
3/ Initiation of use of deferred supply within ten-year interest free period.
N. A. = not applicable.

j. Effect of project on state and local governments. There are no major changes expected in the cost of state and local government services as a result of the Tocks Island Project. Any increased costs of state and local services associated with the project have been taken into account in the estimate of annual operation and maintenance costs for the project. While there may be reductions in the tax revenues resulting from Federal acquisition of lands in the Tocks Island Project area, it is expected that such reductions would be more than compensated for through increased activity, directly and indirectly associated with the multiple-purpose development features of the Tocks Island Project. In the case of the conventional hydropower facilities, recommended for Federal development, Federal, state and local taxes estimated at $335,000 annually will be foregone. The effects of these taxes were taken into account in project formulation and in the computation of benefit-cost ratios shown in paragraph 8d.

9. AQUASHICOLA PROJECT.

a. Description. The Aquashicola Project site is located on Aquashicola Creek about 4-1/2 miles upstream from its confluence with Lehigh River and about 3 miles east of Palmerton, Pennsylvania. The proposed project would be a multiple-purpose development to provide supplies of water, flood control and recreation. Reservoir capacity to spillway crest level would be 45,000 acre-feet; 1,000 acre-feet inactive, 24,000 acre-feet for supplies of water and recreation, and 20,000 acre-feet for flood control. It would be formed by an earth dam 2,000 feet long and rising 110 feet above the creek bed, and have a concrete spillway located in the south wing of the dam and gate-controlled outlet works discharging through sluices in the spillway section. The project would contribute to: (1) the satisfaction of the future water supply needs of downstream areas especially the Allentown-Bethlehem and the Trenton-Philadelphia areas; (2) the reduction in flood damages of especial importance to the highly industrialized Allentown, Bethlehem and Easton areas; and (3) the satisfaction of the desire for nonurban recreation facilities of the surrounding population. The Aquashicola Project would be required by the year 1981.

b. Economic life. The economic life of the Aquashicola Project as used in project analysis is 50 years.

c. Project costs. The estimated cost of construction, excluding $488,000 for indirectly related recreation, is $19,000,000; the cost of operation and maintenance is $82,000 annually; and the cost of replacement is $2,000 annually. All costs are computed on the basis of 1959 price levels.

d. Benefit-cost ratios. Benefit-cost ratios were computed using total tangible benefits and total costs reflecting various interest rates applied to Federal and non-Federal interests for 50 years and 100 years. The benefit-cost ratio of the Aquashicola Project for a 50-year economic life is 1.1 and for a 100-year economic life it is 1.3. Capital costs, operation and maintenance costs, replacement costs, and benefits for 50 years and 100 years are as follows:

	Amortization Period	
	50 Years	100 Years
CONSTRUCTION EXPENDITURES	$19,000,000	$19,000,000
ANNUAL CHARGES		
Interest and Amortization (including interest during construction)	769,000	625,000
Operation & Maintenance	82,000	82,000
Major Replacements	2,000	3,000
Economic Cost of Land	21,000	19,000
Total Annual Charges	874,000	730,000
ANNUAL BENEFITS		
Reduction of Flood Damages	293,000	299,000
Recreation, directly related	159,000	159,000
Supplies of Water	484,000	498,000
Total Annual Benefits	936,000	956,000
BENEFIT-COST RATIO	1.1	1.3

Notes: Costs and benefits for indirectly related recreation are excluded.
All amounts rounded; totals may not agree with sums of individual items due to rounding.
Interest rate of 2-5/8% used in determination of annual costs, where applicable, and discounting of future benefits.

e. Intangible project effects. Intangible project effects of the Aquashicola Project would include: a contribution to the prevention of loss of life, which amounted to 99 lives lost throughout the Delaware River Basin in the August 1955 flood; assurance values from assigning adequate flood control storage capacity at the Aquashicola Project to control 77% of the standard project flood to non-damaging proportions so as to avoid a false sense of security from floods among the residents in the urban downstream reaches; and the value of the provision for sufficient site development at the Aquashicola Project to insure the realization of optimum recreation benefits. Adverse effects resulting from the Aquashicola Project would essentially be a consequence of the damages expected to fish and wildlife resources in the project area. There is presented in appendix J to this report the acres of land and miles of stream that would be required to replace these resources in kind. No monetary equivalent for means of recovering such damages is presented.

f. Physical feasibility and cost of providing for future needs. The Aquashicola Project has been formulated to contribute to the satisfaction of current and future needs for reduction of flood damages, recreation, and supplies of water over the economic life of the project. No provision has been made for later or phased construction at the Aquashicola Project to satisfy known additional future requirements in the area served by the project since it was

found uneconomic to do so. System analyses for the four recommended major control projects in the Lehigh River Basin, namely, Beltzville, Trexler, Aquashicola and Bear Creek, indicated that the satisfaction of additional and future requirements would be more economically achieved through the orderly development of the Beltzville, Trexler, and Bear Creek Projects, as recommended herein, than through the extension of the scale of development or phased construction of the Aquashicola Project.

g. Allocations of costs. Allocation of costs were computed by (1) the separable costs-remaining benefits method, (2) the priority of use method, and (3) the incremental cost method on two time periods for amortization, 50 years and 100 years. The cost allocation data are shown in table AA-6. In the incremental cost method of allocation, supply of water was considered the basic function because the schedule date for development of the project is based on the anticipated need for supplies of water.

h. Extent of interest in project. In order to take into account the desires and views of Federal agencies, affected states and municipalities, during the survey and the preparation of the survey report, the District Engineer formally established the Delaware Basin Survey Coordinating Committee. This Committee was comprised of representatives of the States of Pennsylvania, New York, New Jersey, and Delaware; of the cities of Philadelphia and New York; and of the various Federal agencies concerned with water resources. Ten meetings of the Committee, which were open to the public, were held at about four-month intervals from April 1957 to March 1960 at various points throughout the Delaware River Basin and service area. Federal agencies, states and municipalities were informed at these various meetings as to the progress of the study and given the opportunity to review and comment on the features of the comprehensive plan. Also, a formal review procedure assured each member of the Coordinating Committee ample time to comment on the major features of the studies as they were reported on in the 24 appendices to the report. At the conclusion of the studies four public hearings were held in the basin to advise local interests of the findings of the study and afford them opportunities to express their views. It is believed that these interests are in general agreement with the plan presented. Under the review procedures prescribed for this survey report local interests will have additional opportunity for comment on the features of the plan and cost sharing arrangements. Federal participation in this project has been estimated at $8,540,000 for construction expenditures and $51,000 annually for operation, maintenance and replacement during the period of deferred use of future water supplies and $40,000 annually after use of the future water supplies is initiated.

TABLE AA-6

ALLOCATIONS OF COST FOR AQUASHICOLA PROJECT[1/]

(All amounts rounded; totals may not agree with sums of individual items due to rounding)

	Amortization Period - 50 Years				Amortization Period - 100 Years			
	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total
SEPARABLE COSTS - REMAINING BENEFITS METHOD								
1. BENEFITS	$ 293,000	$ 159,000	$ 485,000	$ 937,000	$ 300,000	$ 159,000	$ 499,000	$ 958,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	271,000	94,000	435,000	800,000	226,000	70,000	346,000	642,000
b. Annual O&M and Replacement Costs	28,000	13,000	44,000	85,000	29,000	12,000	44,000	86,000
c. Specific Use Construction Expenditures	-	878,000	-	878,000	-	878,000	-	878,000
d. Joint-Use Facility Constr. Expenditures	6,490,000	1,170,000	10,400,000	18,100,000	6,750,000	953,000	10,400,000	18,100,000
e. Total Constr. Expenditures (First Cost)	6,490,000	2,050,000	10,400,000	19,000,000	6,750,000	1,830,000	10,400,000	19,000,000
PRIORITY OF USE METHOD 2/								
1. BENEFITS	293,000	159,000	485,000	937,000	300,000	159,000	499,000	958,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	293,000	104,000	402,000	800,000	300,000	96,000	247,000	642,000
b. Annual O&M and Replacement Costs	30,000	14,000	41,000	85,000	38,000	16,000	32,000	86,000
c. Specific Use Construction Expenditures	-	878,000	-	878,000	-	878,000	-	878,000
d. Joint-Use Facility Constr. Expenditures	7,040,000	1,410,000	9,660,000	18,100,000	9,000,000	1,690,000	7,420,000	18,100,000
e. Total Constr. Expenditures (First Cost)	7,040,000	2,290,000	9,660,000	19,000,000	9,000,000	2,570,000	7,420,000	19,000,000
INCREMENTAL COST METHOD 3/								
1. BENEFITS	293,000	159,000	485,000	937,000	300,000	159,000	499,000	958,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	165,000	46,000	589,000	800,000	132,000	39,000	471,000	642,000
b. Annual O&M and Replacement Costs	17,000	8,000	60,000	85,000	17,000	8,000	60,000	86,000
c. Specific Use Construction Expenditures	-	878,000	-	878,000	-	878,000	-	878,000
d. Joint-Use Facility Constr. Expenditures	3,920,000	-	14,200,000	18,100,000	3,920,000	-	14,200,000	18,100,000
e. Total Constr. Expenditures (First Cost)	3,920,000	878,000	14,200,000	19,000,000	3,920,000	878,000	14,200,000	19,000,000

1/ Fish and Wildlife benefits and costs discussed in Appendix J. No monetary equivalent given.
2/ Priority for assigning remaining costs: (1) reduction of flood damages; (2) directly related recreation; (3) supplies of water.
3/ Supplies of water considered the basic function to which all remaining costs are assigned.
NOTE: Interest rate of 2½% used in determination of annual costs and in discounting of future benefits.

i. Repayment schedules for reimbursable costs. The reimbursable cost for the Aquashicola Project would include a construction cost of $10,400,000 for supplies of water. Alternative repayment schedules acceptable to the Federal government for recovery of this cost are shown below:

Function	Construction Expenditures	Lump Sum	Annual 1/ Payment	Deferred Lump Sum	Deferred 1/ Annual Payment
Supplies of Water	$10,400,000 (rounded)				
Current Supply	4,753,000	$4,753,000	$178,000	N.A.	N.A.
Deferred Supply	5,696,000	5,696,000	214,000	$5,696,000 2/	$214,000

1/ Assumes Federal financing of such costs at 2-5/8%, amortization period 50 years.
2/ Initiation of use of deferred supply within ten-year interest free period.
N. A. - not applicable.

In addition, non-Federal interests would be required to contribute $34,000 annually for the cost of operation, maintenance and replacement during the period of deferred use of future water supplies and $44,000 annually after use of the future water supply is initiated.

j. Effect of project on state and local governments. There are no major changes expected in the cost of state and local government services as a result of the Aquashicola Project. Any increased costs of state and local services associated with the project have been taken into account in the estimate of annual operation and maintenance costs for the project. While there may be reductions in the tax revenues resulting from Federal acquisition of lands in the Aquashicola Project area, it is expected that such reduction would be more than compensated for through increased activity, directly and indirectly associated with the multiple-purpose development features of the Aquashicola Project.

10. MAIDEN CREEK PROJECT

a. Description. The Maiden Creek Project site is located on Maiden Creek about 1/3 mile upstream from its confluence with Moselem Creek and about 12 miles north of Reading, Pennsylvania. The proposed project would be a multiple-purpose development to provide supplies of water, flood control and recreation. Reservoir capacity to spillway crest level would be 114,000 acre-feet; 2,000 acre-feet inactive, 74,000 acre-feet for supplies of water and recreation, and 38,000 acre-feet for flood control. It would be formed by an earth and rock fill dam 2,600 feet long and rising 110 feet above the creek bed, and have a spillway about 400 feet east of the dam and gate-controlled outlet works discharging through a conduit on rock along the left abutment. The project would contribute to: (1) the satisfaction of the future water supply needs of downstream areas especially the Reading-Pottstown and Philadelphia areas; (2) the reduction in flood damages of especial importance to such damage centers as Reading, Pottstown, Norristown, and Philadelphia; and (3) the satisfaction of the desire for nonurban recreation facilities of the surrounding population. The Maiden Creek Project would be required by the year 1982.

b. Economic life. The economic life of the Maiden Creek Project as used in project analysis is 50 years.

c. Project costs. The estimated cost of construction, excluding $3,250,000 for indirectly related recreation, is $27,600,000; the estimated cost of operation and maintenance is $130,000 annually; and the estimated cost of major replacement is $7,000 annually. All costs are computed on the basis of 1959 price levels.

d. Benefit-cost ratios. Benefit-cost ratios were computed using total tangible benefits and total costs reflecting various interest rates applied to Federal and non-Federal interests for 50 years and 100 years. The benefit-cost ratio of the Maiden Creek Project for a 50-year economic life is 1.1 and for a 100-year economic life it is 1.3. Capital costs, operation and maintenance costs, replacement costs, and benefits for 50 years and 100 years are as follows:

	Amortization Period	
	50 Years	100 Years
CONSTRUCTION EXPENDITURES	$27,600,000	$27,600,000
ANNUAL CHARGES		
Interest and Amortization (including interest during construction	1,170,000	965,000
Operation and Maintenance	130,000	130,000
Major Replacements	7,000	10,000
Economic Cost of Lands	76,000	69,000
Total Annual Charges	1,390,000	1,180,000
ANNUAL BENEFITS		
Reduction of Flood Damages	243,000	254,000
Recreation, directly related	424,000	424,000
Supplies of Water	826,000	903,000
Total Annual Benefits	1,490,000	1,580,000
BENEFIT-COST RATIO	1.1	1.3

Notes: Costs and benefits for indirectly related recreation are excluded.
All amounts rounded, totals may not agree with sums of individual items due to rounding.
Interest rate of 2-5/8%, used in determination of annual costs, where applicable, and discounting of future benefits.

e. Intangible project effects. Intangible project effects of the Maiden Creek Project include: a contribution to the prevention of loss of life, which amounted to 99 lives lost throughout the Delaware River Basin in the August 1955 flood; assurance values from assigning adequate flood control storage capacity at the Maiden Creek Project to control 55% of the standard project flood to non-damaging proportions so as to avoid a false sense of security from floods among the residents in the urban downstream reaches; and the value of the provision for sufficient site development at the Maiden Creek Project to insure the realization of optimum recreation benefits. Adverse effects resulting from the Maiden Creek Project would essentially be a consequence of the damages expected to fish and wildlife resources in the project area. There is presented in appendix J to this report the acres of land that would be required to replace wildlife resources in kind. No monetary equivalent for means of recovering such damages is presented.

f. Physical feasibility and cost of providing for future needs. The Maiden Creek Project has been formulated to contribute to the satisfaction of current and future needs for reduction of flood damages, recreation, and supplies of water over the economic life of the project. No provision has been made for later or phased construction at the Maiden Creek Project to satisfy known additional future requirements in the area served by the project since it was found uneconomic to do so. Analysis of the water control requirements in the Schuylkill River Basin indicated that the satisfaction of additional or future requirements would be more economically

achieved through the orderly development of the Blue Marsh Project, as recommended herein, than through the extension of the scale of development or phased construction of the Maiden Creek Project.

g. Allocations of costs. Allocation of costs were computed by (1) the separable costs-remaining benefits method, (2) the priority of use method, and (3) the incremental cost method on two time periods for amortization, 50 years and 100 years. The cost allocation data are shown in table AA-7. In the incremental cost method of allocation, supply of water was considered the basic function because the scheduled date for development of the project is based on the anticipated need for supplies of water.

h. Extent of interest in project. In order to take into account the desires and views of Federal agencies, affected states and municipalities, during the survey and the preparation of the survey report, the District Engineer formally established the Delaware Basin Survey Coordinating Committee. This Committee was comprised of representatives of the States of Pennsylvania, New York, New Jersey, and Delaware; of the cities of Philadelphia and New York; and of the various Federal agencies concerned with water resources. Ten meetings of the Committee, which were open to the public, were held at about four-month intervals from April 1957 to March 1960, at various points throughout the Delaware River Basin and service area. Federal agencies, states and municipalities were informed at these various meetings as to the progress of the study and given the opportunity to review and comment on the features of the comprehensive plan. Also, a formal review procedure assured each member of the Coordinating Committee ample time to comment on the major features of the studies as they were reported on in the 24 appendices to the report. At the conclusion of the studies four public hearings were held in the basin to advise local interests of the findings of the study and afford them opportunities to express their views. It is believed that these interests are in general agreement with the plan presented. Under the review procedures prescribed for this survey report local interests will have additional opportunity for comment on the features of the plan and cost sharing arrangements. Federal participation in this project has been estimated at $9,750,000 for construction expenditures, and $94,000 annually for operation, maintenance and replacement during the period of deferred use of future water supplies and $83,000 annually after use of the future water supplies is initiated.

i. Repayment schedules for reimbursable costs. The reimbursable cost for the Maiden Creek Project includes a construction cost of $17,800,000 for supplies of water. Alternative re-

TABLE AA-7

ALLOCATIONS OF COST FOR MAIDEN CREEK PROJECT 1/

(All amounts rounded; totals may not agree with sums of individual items due to rounding)

	Amortization Period - 50 Years				Amortization Period - 100 Years			
	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total
SEPARABLE COSTS - REMAINING BENEFITS METHOD								
1. BENEFITS	$ 244,000	$ 424,000	$ 833,000	$ 1,500,000	$ 255,000	$ 424,000	$ 910,000	$ 1,590,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	233,000	256,000	733,000	1,220,000	200,000	205,000	587,000	992,000
b. Annual O & M and Replacement Costs	17,000	66,000	55,000	138,000	18,000	68,000	55,000	141,000
c. Specific Use Construction Expenditures	-	2,440,000	-	2,440,000	-	2,440,000	-	2,440,000
d. Joint-Use Facility Constr. Expenditures	5,610,000	1,700,000	17,800,000	25,200,000	6,060,000	1,160,000	17,900,000	25,200,000
e. Total Constr. Expenditures (First Cost)	5,610,000	4,140,000	17,800,000	27,600,000	6,060,000	3,600,000	17,900,000	27,600,000
PRIORITY OF USE METHOD 2/								
1. BENEFITS	244,000	424,000	833,000	1,500,000	255,000	424,000	910,000	1,590,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	244,000	279,000	700,000	1,220,000	255,000	255,000	482,000	992,000
b. Annual O & M and Replacement Costs	18,000	68,000	52,000	138,000	24,000	72,000	45,000	141,000
c. Specific Use Construction Expenditures	-	2,440,000	-	2,440,000	-	2,440,000	-	2,440,000
d. Joint-Use Facility Constr. Expenditures	5,910,000	2,280,000	17,000,000	25,200,000	7,780,000	2,670,000	14,700,000	25,200,000
e. Total Constr. Expenditures (First Cost)	5,910,000	4,720,000	17,000,000	27,600,000	7,780,000	5,110,000	14,700,000	27,600,000
INCREMENTAL COST METHOD 3/								
1. BENEFITS	244,000	424,000	833,000	1,500,000	255,000	424,000	910,000	1,590,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	198,000	187,000	836,000	1,220,000	158,000	167,000	666,000	992,000
b. Annual O & M and Replacement Costs	15,000	61,000	62,000	138,000	15,000	64,000	62,000	141,000
c. Specific Use Construction Expenditures	-	2,440,000	-	2,440,000	-	2,440,000	-	2,440,000
d. Joint-Use Facility Constr. Expenditures	4,770,000	-	20,400,000	25,200,000	4,770,000	-	20,400,000	25,200,000
e. Total Constr. Expenditures (First Cost)	4,770,000	2,440,000	20,400,000	27,600,000	4,770,000	2,440,000	20,400,000	27,600,000

1/ Fish and Wildlife benefits and costs discussed in Appendix J. No monetary equivalent given.

2/ Priority for assigning remaining costs: (1) reduction of flood damages; (2) directly related recreation; (3) supplies of water.

3/ Supplies of water considered the basic function to which all remaining costs are assigned.

NOTE: Interest rate of 2½% used in determination of annual costs and in discounting of future benefits.

payment schedules acceptable to the Federal government for recovery of this cost are shown below:

Function	Construction Expenditures	Lump Sum	Annual Payment 1/	Deferred Lump Sum	Deferred Annual Payment 1/
Supplies of Water	$17,800,000 (rounded)				
Current Supply	9,570,000	$9,570,000	$360,000	N. A.	N. A.
Deferred Supply	8,279,000	8,279,000	311,000	$8,948,000 2/	$336,000

1/ Assumes Federal financing of such costs at 2-5/8%, amortization period 50 years.

2/ Initiation of use of deferred supply estimated at 13 years after project completion. Accrual of 3 years interest added to deferred supply total cost.

N. A. - not applicable.

In addition, non-Federal interests would be required to contribute $44,000 annually for the cost of operation, maintenance and replacement during the period of deferred use of future water supplies and $55,000 annually after use of the future water supply is initiated.

j. Effect of project on state and local governments. There are no major changes expected in the cost of state and local government services as a result of the Maiden Creek Project. Any increased costs of state and local services associated with the project have been taken into account in the estimate of annual operation and maintenance costs for the project. While there may be reductions in the tax revenues resulting from Federal acquisition of lands in the Maiden Creek Project area, it is expected that such reduction would be more than compensated for through increased activity, directly and indirectly associated with the multiple-purpose development features of the Maiden Creek Project.

11. BEAR CREEK PROJECT.

a. Description. The Bear Creek Project is a modification of the single-purpose flood control project with incidental recreation use now under construction, which is located on Lehigh River 75 miles above its confluence with Delaware River and about 5 miles north of White Haven, Pennsylvania. The proposed project would be a multiple-purpose development to provide for supplies of water and recreation in addition to the present flood control purpose. Reservoir capacity to spillway crest level would be 180,000 acre-feet; 2,000 acre-feet inactive, 70,000 acre-feet for supplies of water and recreation, and 108,000 acre-feet for flood control. The proposed modification would require alteration of the spillway, increasing the height of the dam, extending the outlet tunnel by the addition of a concrete conduit, and constructing new and raising the heights of existing dikes. The modified dam would rise 263 feet above the river bed and be 3,500 feet long. The modified project would contribute to: (1) the satisfaction of the future water supply needs of downstream areas especially the Allentown-Bethlehem and the Trenton-Philadelphia areas; (2) the reduction in flood damages in the downstream areas of especial importance to the highly industrialized Allentown, Bethlehem, and Easton areas; and (3) the satisfaction of the desire for nonurban recreation facilities of the surrounding population. The Bear Creek Project would be required by the year 1989.

b. Economic life. The economic life of the Bear Creek Project from the time modifications are completed and including features of the existing project as used in project analysis is 50 years.

c. Project costs. The estimated cost of construction, excluding $875,000 for indirectly related recreation, is $20,100,000, which is made up of $11,100,000 for the cost of the project now under construction and $8,990,000 for the cost of modifications for multiple-purpose development. The total new construction expenditure required, including $4,460,000 for rehabilitation of the existing project would be $13,400,000. The estimated annual operation and maintenance cost is $117,000 and the estimated major replacement cost is $3,000 annually. All costs are computed on the basis of 1959 price levels.

d. Benefit-cost ratios. Benefit-cost ratios were computed using total tangible benefits and total costs reflecting various interest rates applied to Federal and non-Federal interests for 50 years and 100 years. The economic justification for the Bear Creek Project was based on the premise that the modification constituted a second stage of development and rehabilitation to provide feasible comprehensive development with a 50-year life expectancy. The benefit-cost ratio of the Bear Creek Project for a 50-year economic life is 2.6 and for a 100-year economic life it is 3.3. Capital costs,

operation and maintenance costs, replacement costs and benefits for 50 years and 100 years are as follows:

	Amortization Period	
	50 Years	100 Years
NEW CONSTRUCTION EXPENDITURES	$ 13,400,000	$ 13,400,000
ANNUAL CHARGES		
Interest and Amortization (including interest during construction)	577,000	467,000
Operation and Maintenance	117,000	117,000
Major Replacements	3,000	4,000
Economic Cost of Land	17,000	16,000
Total Annual Charges	714,000	603,000
ANNUAL BENEFITS		
Reduction of Flood Damages	427,000	427,000
Recreation, directly related	161,000	161,000
Supplies of Water	1,290,000	1,380,000
Total Annual Benefits	1,880,000	1,970,000
BENEFIT-COST RATIO	2.6	3.3

Notes: Costs and benefits for indirectly related recreation are excluded.
All amounts rounded; totals may not agree with sums of individual items due to rounding.
Interest rate of 2-5/8% used in determination of annual costs, where applicable, and discounting of future benefits.

e. Intangible project effects. Intangible project effects of the Bear Creek Project would include: a contribution to the prevention of loss of life, which amounted to 99 lives lost throughout the Delaware River Basin in the August 1955 flood; assurance values from assigning adequate flood control storage capacity at the Bear Creek Project to completely control the standard project flood to non-damaging proportions so as to avoid a false sense of security from floods among the residents in the urban downstream reaches; and the value of the provision for sufficient site development at Bear Creek Project to insure the realization of optimum recreation benefits. Adverse effects resulting from the Bear Creek Project essentially would be a consequence of the damages expected to fish and wildlife resources in the project area. There is presented in appendix J to this report a discussion of how such damages attributable to other projects in the plan of development might be mitigated. No monetary equivalent for means of recovering such damages is presented.

f. Physical feasibility and cost of providing for future needs. The Bear Creek Project has been formulated to contribute to the satisfaction of current and future needs for reduction of flood

damages, recreation, and supplies of water over the economic life of the project. No provision has been made for further modification at the Bear Creek Project to satisfy known additional future requirements in the area served by this project since it was found uneconomic to do so.

g. Allocation of costs. Allocation of costs were computed by (1) the separable costs-remaining benefits method, (2) the priority of use method, and (3) the incremental cost method on two time periods for amortization, 50 years and 100 years. The cost allocation data are shown in table AA-8. In the incremental cost method of allocation, supply of water was considered the basic function because the scheduled date for development of the project is based on the anticipated need for supplies of water.

h. Extent of interest in project. In order to take into account the desires and views of Federal agencies, affected states and municipalities, during the survey and the preparation of the survey report, the District Engineer formally established the Delaware Basin Survey Coordinating Committee. This Committee was comprised of representatives of the States of Pennsylvania, New York, New Jersey, and Delaware; of the cities of Philadelphia and New York; and of the various Federal agencies concerned with water resources. Ten meetings of the Committee, which were open to the public, were held at about four-month intervals from April 1957 to March 1960 at various points throughout the Delaware River Basin and service area. Federal agencies, states and municipalities were informed at these various meetings as to the progress of the study and given the opportunity to review and comment on the features of the comprehensive plan. Also, a formal review procedure assured each member of the Coordinating Committee ample time to comment on the major features of the studies as they were reported on in the 24 appendices to the report. At the conclusion of the studies four public hearings were held in the basin to advise local interests of the findings of the study and afford them opportunities to express their views. It is believed that these interests are in general agreement with the plan presented. Under the review procedures prescribed for this survey report, local interests will have additional opportunity for comment on the features of the plan and cost sharing arrangements. Federal participation in this project has been estimated at $4,330,000 for new construction expenditures, and $85,000 annually for operation, maintenance, and replacement costs during the period of deferred use of future water supplies and a total of $55,000 annually after use of the future water supplies is initiated.

i. Repayment schedules for reimbursable costs. The reimbursable cost for the Bear Creek Project would include a construction cost of $9,110,000 for supplies of water. Alternate

TABLE AA-8

ALLOCATIONS OF COST FOR BEAR CREEK PROJECT 1/

(All amounts rounded; totals may not agree with sums of individual items due to rounding)

	Amortization Period - 50 Years				Amortization Period - 100 Years			
	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total	Reduction of Flood Damages	Recreation (Directly Related)	Supplies of Water	Total
SEPARABLE COSTS - REMAINING BENEFITS METHOD								
1. BENEFITS	$1,060,000	$ 161,000	$ 1,300,000	$ 2,520,000	$ 1,060,000	$161,000	$ 1,390,000	$ 2,610,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	409,000	60,000	404,000	872,000	323,000	53,000	330,000	706,000
b. Annual O & M and Replacement Costs	31,000	25,000	64,000	120,000	31,000	26,000	65,000	121,000
c. Specific Use Construction Expenditures	-	595,000	-	595,000	-	595,000	-	595,000
d. Joint-Use Facility Constr. Expenditures	10,100,000	229,000	9,110,000	19,500,000 2/	10,100,000	210,000	9,170,000	19,500,000 2/
e. Total Const. Expenditures (First Cost)	10,100,000	824,000	9,110,000	20,100,000 2/	10,100,000	805,000	9,170,000	20,100,000 2/
PRIORITY OF USE METHOD 3/								
1. BENEFITS	1,060,000	161,000	1,300,000	2,520,000	1,060,000	161,000	1,390,000	2,610,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	454,000	105,000	313,000	872,000	361,000	96,000	248,000	706,000
b. Annual O&M and Replacement Costs	53,000	30,000	37,000	120,000	53,000	32,000	36,000	121,000
c. Specific Use Construction Expenditures	-	595,000	-	595,000	-	595,000	-	595,000
d. Joint-Use Facility Constr. Expenditures	10,700,000	1,340,000	7,400,000	19,500,000 2/	10,600,000	1,530,000	7,310,000	19,500,000 2/
e. Total Const. Expenditures (First Cost)	10,700,000	1,940,000	7,400,000	20,100,000 2/	10,600,000	2,120,000	7,310,000	20,100,000 2/
INCREMENTAL COST METHOD 4/								
1. BENEFITS	1,060,000	161,000	1,300,000	2,520,000	1,060,000	161,000	1,390,000	2,610,000
2. ALLOCATION OF COSTS:								
a. Annual Economic Costs	398,000	49,000	425,000	872,000	316,000	44,000	346,000	706,000
b. Annual O & M and Replacement Costs	30,000	23,000	67,000	120,000	30,000	24,000	67,000	121,000
c. Specific Use Construction Expenditures	-	595,000	-	595,000	-	595,000	-	595,000
d. Joint-Use Facility Constr. Expenditures	9,920,000	-	9,570,000	19,500,000 2/	9,920,000	-	9,570,000	19,500,000 2/
e. Total Const. Expenditures (First Cost)	9,920,000	595,000	9,570,000	20,100,000 2/	9,920,000	595,000	9,570,000	20,100,000 2/

1/ Fish and wildlife benefits and costs discussed in Appendix J. No monetary equivalent given.
2/ Includes existing flood control project cost of $11,100,000.
3/ Priority for assigning remaining costs: (1) reduction of flood damages, (2) directly related recreation, (3) supplies of water.
4/ Supplies of water considered the basic function to which all remaining costs are assigned.
NOTE: Interest rate of 2½% used in determination of annual costs and discounting of future benefits.

repayment schedules acceptable to the Federal government for the recovery of this cost are shown below:

Function	Construction Expenditure	Lump Sum	Annual Payment 1/	Deferred Lump Sum	Deferred Annual Payment 1/
Supplies of Water	$9,110,000 (rounded)				
Current Supply	3,087,000	$3,087,000	$116,000	N. A.	N. A.
Deferred Supply	6,026,000	6,026,000	226,000	$6,026,000 2/	$226,000

1/ Assumes Federal financing of such costs at 2-5/8%, amortization period 50 years.

2/ Initiation of use of deferred supply within ten-year interest free period.

N. A. = not applicable.

In addition, non-Federal interests would be required to contribute $34,000 annually for the cost of operation, maintenance and replacement during the period of deferred use of future water supplies and $64,000 annually after use of the future water supplies is initiated.

j. Effect of project on state and local governments. There are no major changes expected in the cost of state and local government services as a result of the Bear Creek Project. Any increased costs of state and local services associated with the project have been taken into account in the estimate of annual operation and maintenance costs for the project. While there may be reductions in the revenues resulting from Federal acquisition of lands in the Bear Creek Project area, it is expected that such reductions would be more than compensated for through increased activity, directly and indirectly associated with the multiple-purpose development features of the Bear Creek Project.

D E L E T I O N S

Paragraphs 12, 13 and 14 previously appearing on Pages AA-43 thru AA-48 have been deleted.